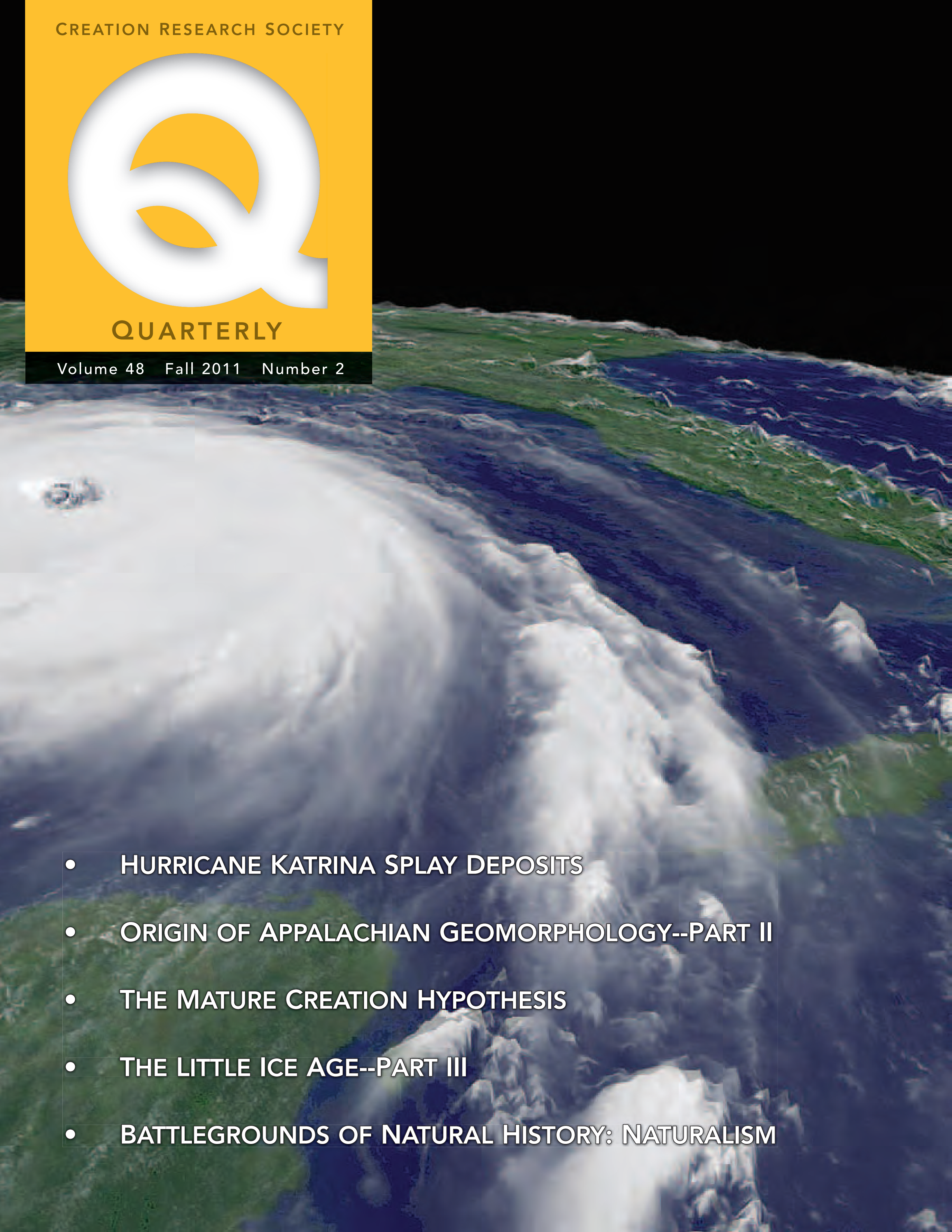
CREATION RESEARCH SOCIETY

Q

QUARTERLY

Volume 48 Fall 2011 Number 2



- HURRICANE KATRINA SPLAY DEPOSITS
- ORIGIN OF APPALACHIAN GEOMORPHOLOGY--PART II
- THE MATURE CREATION HYPOTHESIS
- THE LITTLE ICE AGE--PART III
- BATTLEGROUNDS OF NATURAL HISTORY: NATURALISM

Creation Research Society Quarterly

Volume 48
Number 2
Fall 2011

Articles

Origin of Appalachian Geomorphology Part II: Formation of Surficial Erosion Surfaces 105
Michael J. Oard

Hurricane Katrina Splay Deposits: Hydrodynamic Constraints on Hyperconcentrated Sedimentation and Implications for the Rock Record 123
W.R. Barnhart

Battlegrounds of Natural History: Naturalism 147
John K. Reed, Emmett L. Williams

The Case for the Mature Creation Hypothesis 168
Jerry Bergman

Author and Title Index for Volume 47, 2010–2011 178
Lazella M. Lawson

Departments

Editorial: Not So Secret 100

Notes from the Panorama of Science 183
  Blackbody Radiation and Creation 183

Letters to the Editor 186
  Setting the Record Straight 186
  The Age of the Oldest Placental Mammal Means Evolution is Wrong! 186

Instructions to Authors 187

Membership/Subscription Application and Renewal Form 189

Order Blank for Past Issues 190

Haec Credimus

For in six days the Lord made heaven and earth, the sea, and all that in them is, and rested on the seventh.—Exodus 20:11

Creation Research Society Quarterly

Volume 48
Number 2
Fall 2011

Cover design by Michael Erkel:
Michael Erkel and Associates, 1171 Carter Street,
Crozet, Virginia 22932

Design services by Cindy Blandon, cblandon@aol.com

The *Creation Research Society Quarterly* is published by the Creation Research Society, 6801 N. Highway 89, Chino Valley, AZ 86323, and it is indexed in the *Christian Periodical Index* and the *Zoological Record*.

Send papers on all subjects to the Editor:
CRSQeditor@creationresearch.org or to
Kevin L. Anderson, Van Andel Creation Research
Center, 6801 N. Highway 89, Chino Valley, AZ 86323.

Send book reviews to the Book Review Editor:
Don B. DeYoung, 200 Seminary Dr.,
Winona Lake, IN 46590, dbdeyoung@grace.edu.

All authors' opinions expressed in the *Quarterly* are not necessarily the opinions of the journal's editorial staff or the members of the Creation Research Society

Copyright © 2011 by Creation Research Society. All rights to the articles published in the *Creation Research Society Quarterly* are reserved to the Creation Research Society. Permission to reprint material in any form, including the Internet, must be obtained from the Editor.

ISSN 0092-9166

Printed in the United States of America

***CRSQ* Editorial Staff**
Kevin L. Anderson, Editor
Bill Barrick, Biblical Studies Editor
Jerry Bergman, Biology Editor
Don B. DeYoung, Book Review Editor
Eugene F. Chaffin, Physics Editor
George F. Howe, Assistant Biology Editor
Jean K. Lightner, Biology Editor
Robert Mullin, Assistant Managing Editor
John K. Reed, Geology Editor
Ronald G. Samec, Astronomy Editor
Theodore Siek, Biochemistry Editor
Jarl Waggoner, Managing Editor

CRS Board of Directors
Don B. DeYoung, President
Eugene F. Chaffin,Vice-President
Glen W. Wolfrom, Membership Secretary
Danny Faulkner, Treasurer
Mark Armitage, Financial Secretary
Gary H. Locklair, Recording Secretary
Robert Hill
D. Russell Humphreys
David A. Kaufmann
Jean K. Lightner
Michael J. Oard
John K. Reed
David Rodabaugh
Ronald G. Samec

Editorial

Not So Secret

"Have you read the book, *The Secret*?"

"No, what's it about?"

"It explains what is going wrong in the world and why we fail."

"Really? That is good to know. What does it say is the problem?"

"That most people don't know the secret."

"I guess maybe that is why it has stayed a secret. So, what is this secret?

"The secret is the law of attraction."

"The law of what?"

"The law of attraction."

"What is that?"

"It's a universal law that says that everything is attracted."

"You mean like two people are attracted to each other or like atoms are attracted to other atoms? That kind of attraction?"

"No, I don't think so. The law of attraction draws positive things into our lives."

"Draws positive things? How does it do that?"

"I don't know, but it's a law, and it means that if I think positively, I will draw positive things to me. If I have positive thoughts, then positive things will happen to me."

"This is a law?"

"Yes."

"Did Congress pass this law?"

"Ha, ha. No, it's a universal law."

"I don't understand. How is it universal?"

"If I have positive thoughts about money, and I am always thankful for what I get, then I will get more."

"Get more from where?"

"From the universe. If I am positive to the universe and thankful to the universe, then I will get more."

"So, you mean that if I'm thankful to the universe for what it has given me, then the universe will give me more?"

"Yes."

"Interesting. I did not know the universe had a stash of cash it wanted to give me."

"No, but it uses the law of attraction. If you have positive thoughts, then that attracts positive things, and positive things will happen to you. If I have positive thoughts, then the universe will begin to respond to those positive thoughts. (Quoting from the book) 'Thoughts are magnetic, and thoughts have a frequency. As you think thoughts they are sent into the universe, and they magnetically attract all like things that are on the same frequency. Your thoughts become things. The Universe will start to rearrange itself to make it happen.'"

"Interesting. I didn't know the universe could read my thoughts. Who is this universe? Little green men on Mars with mind-reading equipment?"

"No! The universe is … the universe. All the energy and power in the universe."

"That sounds like pantheism."

"What is pantheism?"

"The idea that God *is* the universe, that there is no personal God, but rather 'god' is a composite of the interactions and forces within the universe."

"I don't understand. God is everywhere. He is the universe."

"Yes, God is *in* all of the universe, but that does not define Him. He is *not* the universe. If you make a cake, it is something you made; but you are not defined or limited by it. You are *not* the cake."

"I don't see that the book teaches pantheism. It's just saying there is this law of attraction."

"What is the source and power of this law?"

"The universe."

"That is pantheism."

"I still don't understand why you say that."

"You believe in God, right?"

"Yes."

"You believe in Christ, right?"

"Yes."

"You believe the Bible is God's Word, right?"

"Yes."

"Then you need to understand that pantheism denies all of that. There is no personal, individual being we know as God. There is no personal relationship with this God. There is no salvation through Christ, because there is no such thing as sin."

"I still don't understand. How does the law of attraction mean there is no sin?"

"Sin is failing to do God's will, failing to meet God's standard. If there is no God, there is no standard to meet. There is no God to sin against."

"Can't the universe have a standard?"

"Where would the universe get a standard?"

"I don't understand."

"How would the universe know what to set as a standard for us? How would it know what is good for us?"

"Maybe it would use the law of attraction …"

So went a recent conversation I had about a book called *The Secret*. Written by Rhonda Byrne, *The Secret* attempts to gain some type of thin credibility by including numerous contributions from self-proclaimed experts of science, business, philosophy, and motivation. This book and its sequel, *The Power*, have been in print for a few years, yet they are still very popular. The first two bookstores I searched had recently sold out of these titles. As of this writing, *The Secret* ranks #1 under the category of mental and spiritual healing and #176 in overall book sales on Amazon.com. Sadly, these books are an excellent example of how easily false ideas can entice and deceive people—even some who claim to be Christians.

In its introduction, *The Secret* claims that the reason Plato, Newton, Beethoven, Edison, and Einstein were successful is because they knew the "secret." How do we know they knew the secret? They were successful. The premise of *The Secret* is that all success comes from what it calls the "law of attraction." Therefore, all successful people (using a worldly standard of "success") must have achieved their success through this law. Unsuccessful people presumably failed to use this law.

At this moment, I might ponder whether Hitler knew the law. Certainly, for nearly a decade he was very successful in his social and political agenda. Did he ultimately fail only after he forgot the law?

What is this secret law of attraction? "The [law of attraction] gives you anything you want: happiness, health, and wealth. … We can have whatever it is that we choose" (Byrne, 2006, p. 1). A grandiose claim. How can this happen?

Mechanistically, Byrne (2006, 2010) states that everything in the universe is composed of energy. All energy has specific frequencies. When we call upon the right frequency, then all the energy of the universe will cause our desires and thoughts to become manifest. If our heart dwells upon positive things, we emit positive frequencies. Like a huge antenna, the universe will receive these positive frequencies and subsequently provide a positive response of wealth, fame, etc. Negative thoughts? Apparently the universe will provide in a negative manner.

Even as I was looking at this book in a bookstore, I was confronted by a true believer. When asked if I had read it yet, I replied, "No." I then received a description of how amazing the law of attraction is and how everything is controlled by our thoughts. Apparently, even traffic signals respond to positive thinking. It was explained to me that I simply had to think positively and lights would turn green. I wondered what would happen to the traffic light if the driver in front of me was having a grumpy day.

The type of positive thinking advocated by *The Secret* and *The Power*, however, is not necessarily all that positive or inspiring. What is so positive about granting the desires of selfish, narcissistic, and ignoble people who lust for wealth and power? In fact, this "law of attraction" seems to cater directly to the most base and carnal desires of humans. What is inspiring about spending all your mental and emotional energy visualizing a new sports car? What is inspiring about shunning those struggling with addictions or personal problems so as not to be contaminated with their negative thoughts? Such philosophy contradicts Christ's example and His teaching to help the poor, the sick, and those in need (Matt. 8:16; 9:10–13; 10:1–3; 25:34–45; Mark 10:21; Luke 5:31; 6:21; 18:22).

The universe is **NOT** an embodiment of God.

God **IS** God.

He is the greatest force in the universe.

And, He most decidedly is **NOT** a feeling.

In fact, *The Secret* claims sickness results exclusively from negative thoughts. "When you open yourself to feel the abundance of the Universe, you'll experience … all the great things that Universe has for you – good health, good wealth, good nature. … Illness cannot exist in a body that has harmonious thoughts" (Byrne, 2006, pp. 126–127, 130). Apparently, Steven Jobs and Christopher Reeves were simply not positive enough in their thinking. I might wonder what it will mean when the author and the various other contributors of this book become ill and die. Was it because they stopped being positive? In fact, for a force so powerful that it can prevent any disease and manifest any thought, it should be mere child's play to recharge a body so that it will never die.

Also, if you are not wealthy, that is because of negative thoughts.

> The only reason any person does not have enough money is because they are *blocking* money from coming to them with their thoughts. … If you do not have enough money, it is because you are stopping the flow of money coming to you … with your thoughts. … To attract money, focus on wealth (Byrne, 2006, p. 99, 111).

We are told by Byrne (2006) that Abraham, Job, and other ancient Hebrews were incredibly wealthy, not because of blessings from God, but because they knew the law of attraction. Even Jesus is claimed to have preached prosperity and lived in affluence (Bryne, 2006).

Difficulties and tragedies are said to result from our negativity too.

> Everything that surrounds your life … you have attracted. Now I know at first blush that's going to be something you hate to hear. You're going to immediately say, "I didn't attract that car accident… ." And I'm here to be a little in your face and to say, yes you did attract it (Byrne, 2006, pp. 27–28).

Whose negative thoughts were responsible for Hurricane Katrina or the Japan tsunami? Apparently, all the victims were guilty.

> [We] recall events in history where masses of lives were lost, and [it seems] incomprehensible that so many people could have attracted themselves to the event. By the law of attraction, they had to be on the same frequency as the event. It does not necessarily mean they thought of the same event, but the frequency of their thoughts matched the frequency of the event (Byrne, 2006, p. 28).

In direct contradiction, Jesus denied that all tragedies and illness are linked to behavior, thoughts, or even personal sin (Matt. 5:45, John 9:1–5, Luke 13:4). And yes, it is hard to imagine—in fact it is simply impossible to imagine—that thousands of people in a specific location all were locked on the same so-called negative thought frequency. Were there none among them on a positive frequency? If so, apparently the law of attraction failed them completely.

What is more, left to our own perspective, concepts of negative and positive can easily become blurred. Who arbitrates what is a positive thought and what is a negative thought? For some, thinking of the sudden death of a harsh and overbearing boss is a very positive experience. Just as the opinion of what is good and what is evil is poorly defined by human standards, what is negative thinking to one person may be very positive to another. What standard does the "universe" use to evaluate whether a person is having a negative thought or a positive thought? Who or what sets the standard? How is this standard applied?

As mentioned before, Adolf Hitler enjoyed great political and social success for nearly a decade. During this time, he wrought unthinkable misery upon millions of people. Was he applying the law of attraction? Was he successful because he was thinking "positive" thoughts? Were his victims reaping the consequence of their negative thinking? Was Hitler's subsequent decline and suicide only because he started thinking negatively?

While reading *The Secret*, it became clear that the concepts of "positive thought" and "good behavior" were being merged. However, without God as a standard for positive and good, evil will reign (Rom. 2:8; 1 John 5:19; Jude 14–16). Without God's discernment, humans easily become confused about what is truly good and what is truly evil (Rom. 14:16; 2 Cor. 4:4; Gal. 5:16–17; Heb. 5:14). In fact, without God, our human desires become decadent and destructive (Rom. 1:24–32; Rom. 3:11–13; Col. 3:5; 1 Tim. 6:9). A universe that simply responds to so-called "frequencies" has no moral discernment and no accountability for any consequences. Only through God can our desires become truly for good and not for our own lusts (Rom. 13:14; Heb. 5:14; 2 Thess. 1:11).

When the "Universe" has the ability to wield such power, it assumes the role of God. Once it assumes this role, does it assume the role of creator as well? Where would the universe get the power of creation?

> The law of attraction is the law of creation. Quantum physicists tell us that the entire Universe emerged from thought! You create your life through your thoughts and the law of attraction. … When you become *aware* of this great law, then you become *aware* of how incredibly powerful you are, to be able to THINK your life into existence (Byrne, 2006, p. 15).

Apparently the power of creation resides in the law of attraction, and the law of attraction was created by thought. Thus, thought becomes the creator. But whose thought? Thought implies—rather, thought *requires* – a thinker. Thought cannot create itself.

Does the universe have thoughts? The only source of thought identified by Byrne (2006, 2010) is human thought. With this "think system," Byrne (2006, p. 15) claims we "think" our "life into existence." By extension, therefore, humans have created themselves. It makes little sense, though, that the law of attraction requires human thought to create the universe, yet the universe had to create humans in order to receive those thoughts.

In reading *The Secret*, I never found any type of logical consistency. Not that "New Age" pantheism worries about such, but the book's author and contributors seem to have some concern about being scientifically consistent. Why? Perhaps they realize people will be more enticed if they think this is some type of scientific law. Appealing to vague generalizations within the loose conjectures of quantum physics, they find sufficient space to let their imaginations fly. This is hardly the basis of a scientific law, but certainly more than sufficient for the true believers and the deceived.

The teachings in *The Secret* require that we consider each of us to be our own "god" and thus able to call upon the powers of the universe (whatever those are) to achieve our hearts' desires. These teachings make the bold claim that if we

> emit a different frequency out into the Universe. The Universe *must* deliver the pictures of the new frequency, no matter how impossible

> the situation might seem … go out into your day and release it to the Universe and trust that the Universe will figure out how to manifest it (Bryne, 2006, pp. 19, 92).

The constant capitalization of the word "Universe" is a clear attempt to empower the universe (i.e., the creation) with divine characteristics, including some mystic "wish-granting" power. Almost like "the Force" in *Star Wars*, this illusory power is at our beckoning to perform miracles simply by our thinking them into existence. A power the Bible clearly declares is held only by God now becomes a power we each possess (if we know and understand how to use it). We are even told to place our trust in the Universe. Thus, through the Universe's power of the so-called law of attraction, we replace God. When we replace God, we then aspire to become like god. This is not a new aspiration, and God warns of its tragic consequences (cf. Isa. 14:12–15).

In fact, *The Secret* brazenly states,

> You are God in a physical body. You are spirit in the flesh. You are Eternal Life expressing itself as You. You are a cosmic being. You are all powerful. You are all wisdom. You are all intelligence. You are perfection. You are magnificence. You are the creator, and you are creating the creation of you on this planet (Bryne, 2006, p. 164).

The arrogance of this claim is mind-boggling. Each of these is a characteristic clearly reserved for God. Assigning them to our own meager existence is as foolish as King Canute attempting to command the tide to stop.

The book's official website makes the additional grand statement that "the greatest power in the universe is a feeling" (www.thesecret.tv). Sadly, many people will read that statement and not even realize what it is really trying to say. Many people who consider themselves Christians will not even recognize that statement is virtual blasphemy.

Creating by thinking? A feeling is the greatest power in the universe? Think it and you will make it happen? Trust the universe?

Let me be very clear. I am NOT God. You are NOT God. The birds and oceans do NOT contain portions of God. God can make the rain, but God is NOT the rain. The universe is NOT an embodiment of God. God IS God. He is the greatest force in the universe. And, He most decidedly is NOT a feeling.

God is not at our beck and call. He has no obligation to grant our wishes, positive or negative. We cannot simply look at Him as some cosmic Santa Claus.

Undoubtedly some disciples of *The Secret* will argue that the Bible says God will give you the desires of your heart. Probably they have heard this comment from others without knowing what the Bible actually says. In Psalm 37, the psalmist states:

> Trust in the LORD and do good; dwell in the land and enjoy safe pasture. Delight yourself in the LORD and he will give you the desires of your heart. Commit your way to the LORD; trust in him and he will do this: He will make your righteousness shine like the dawn, the justice of your cause like the noonday sun. Be still before the LORD and wait patiently for Him (Psalm 37:3–7a, NIV).

This is far different from supporting the teachings of *The Secret*. This passage is absolutely contrary to the foolish idea that our thoughts and desires cause God (or the "universe") to grant our wishes. Only when our heart mirrors the heart of God can we expect Him to grant our desires. Why? His desires are now also our desires.

Genesis 1 also declares that God is the Creator. The Creator is not "thought," not the law of attraction, not the universe, not some silly human idea of a "think system." As Creator, God and God alone has the power to manifest an idea into reality. He alone has the power to provide good for His creation (James 1:17).

It is little wonder that Satan so vigorously opposes all Biblical teachings of Creation. Once God is removed from His role as Creator, then the search begins for a replacement. Satan cares little about whom or what we use as God's replacement, just as long as we replace Him. When God is replaced in our lives, we fill that hole with almost anything else: wealth, power, spiritualism, pantheism, humanism, materialism, or even narcissism. We turn away from the Creator and worship something within the creation (Rom. 1:25). Our hearts then become futile, and we believe a lie (Rom. 1:21–25). This lie includes worshipping things such as the universe, believing ideas such as the so-called law of attraction, striving solely for material possessions, and lusting for carnal gratification.

Personally, I would not want fulfillment or gratification of all my desires. I do not know the future. I do not know what is best for me. Something that might seem wonderful at the moment, God knows is really a harbinger of ill later in my life. I would much rather leave what is best for me in His hands than in my own envious, jealous, and unsteady thinking (James 1:17). In fact, God clearly warns us that our hearts lust after evil. Our cravings are opposed to the love and perfection of God (Rom. 13:14; Gal. 5:16–24; Eph. 2:3). A universe truly under the power of the law of attraction (as described by *The Secret*) would be evil, almost beyond comprehension.

We can easily understand that a positive attitude is healthier both emotionally and physically. People with a positive attitude are more likely to enjoy both professional and personal success. However, *The Secret* exploits this connection far beyond any reasonable link. There will always be examples of people who seem to have had either an extraordinary stroke of luck or skilled dedication. *The Secret* assumes these examples verify its claims. If you are successful, it was because you positively used the law of attraction. If you are not successful, or even suffer personal or professional tragedy, then it assumes you negatively used the law of attraction. This produces a classic form of circular reasoning, with no possible contradictory outcome.

Certainly as Christians we have more reason to be positive than anyone. We have the promise of eternal life. We have the promise of joy—true joy that comes from the love of God, not the acquisition of material possessions or fame. The apostle Paul faced the direst of circumstances with a positive attitude and love in his heart (2 Cor. 6:4–10). But his attitude was grounded in God, not the desire to be famous or rich.

The Secret and *The Power* merely represent the continued assault against the role of God as Creator and our relationship to Him and the rest of His creation. It is nothing new, and it is certainly not a secret. The assault began when Satan first enticed humans to question God's authority and pursue their own desires (Genesis 3). These books offer the same basic claims that Satan has always made. We, not God, know what is best for our lives. We, not God, created our life. We are accountable only to our own desires and thinking.

God warns of such enticing teachings that appeal to our selfish desires and feed our greed (2 Tim. 4:3; 2 Peter 2:15). These self-serving teachings are attractive to many people, but they always lead to destruction. Only a right relationship with our Creator will truly give us what *The Secret* fails to deliver: a fulfilled and rich life.

Kevin Anderson, Ph.D.
Editor
Creation Research
Society Quarterly

References

Byrne, R. 2006. *The Secret*. Altria Books, New York, NY.

Byrne, R. 2010. *The Power.* Altria Books, New York, NY.

Emmett Lewis Williams

1934–2011

Pioneer Creation Scientist

Dr. Emmett Williams passed on to glory April 21, 2011, in Alpharetta, GA. He contributed greatly to the strong heritage of the Creation Research Society, serving on the CRS board of directors for 36 years, 1967–2003. Emmett was CRS vice-president 1973–1982 and president 1994–1999. He also served as *Quarterly* Editor for many years, introducing features including Symposia and Panorama sections. Emmett was honored as a Fellow of the Society in 1990; the June 1991 *Quarterly* was dedicated to him.

A true southern gentleman, Emmett Williams was born in Lynchburg, VA. He served in the Marine Corps 1950–1952, and then earned B.S, M.S. and Ph.D. degrees from Virginia Polytechnic Institute and Clemson University. His specialties were metallurgical and materials engineering. Career contributions included both industry and academics, with teaching and textbook writing at Bob Jones University.

Across the years, the Emmett Williams name is found on scores of CRS *Quarterly* books, articles, reviews and letters (including one of his final articles, starting on p. 147 of this issue). His research efforts include rapid stalactite growth in caves, Grand Canyon geology, thermodynamic laws, and scanning electron microscopy.

On a personal note, Emmett was a true friend, always patient with those of us who were on the learning curve of creation research. He was a colorful and capable chairman of our annual CRS board meetings. We were kept on task with the humorous threat, "If anyone takes off on a rabbit trail, I'll get out my rabbit gun!" Board meetings were always productive and never dull under Emmett's leadership.

Emmett's wife Mary, three children, and grandchildren reside in Georgia. The Williams family is a part of the strength of our nation and of the modern creation movement.

Don B. DeYoung
President, CRS Board of Directors

Origin of Appalachian Geomorphology

Part II: Formation of Surficial Erosion Surfaces

Michael J. Oard*

Abstract

Erosion surfaces on the Piedmont and the Appalachian Plateaus are described. Ridges and valleys in the Valley and Ridge Province are probably not erosion surfaces, forming instead due to lithology differences in the underlying rocks. The "cycle of erosion" invented by William Morris Davis was once popular but has many problems. The currently popular weathering hypothesis is also analyzed and found wanting. The formation of the erosion surfaces with monadnocks and veneers of gravels transported over long distances is best explained by mechanisms associated with the retreating stage of the Flood.

Introduction

In part I, I summarized the general geomorphology of the Appalachians, which includes the Piedmont, Blue Ridge Mountains, Valley and Ridge, and Appalachian Plateaus provinces (Figure 1). Several lines of evidence suggest that up to 6.5 km of erosion occurred, probably as a result of sheet-flow erosion during the retreating stage of the Flood. Although there are several crude methods of estimating the amount of erosion, the most reliable indicator is probably the amount of sediment and sedimentary rock in the offshore area.

During the great erosion episode in the Appalachians, rocks were sometimes planed to flat or nearly flat surfaces, called erosion or planation surfaces. These surfaces have proven controversial among secular geologists but can be readily explained by the mechanisms of the Flood.

Surficial Erosion Surfaces

An erosion surface is defined as: "A land surface shaped and subdued by the action of erosion, esp. by running water. The term is applied to a level or nearly level surface" (Neuendorf et al., 2005, p. 217). A planation surface is generally considered a flat to nearly flat erosion surface. The definition includes erosion by water because many surficial erosion and planation surfaces are capped by a veneer of generally rounded rocks attributed to aqueous action.

Gravel-capped planation surfaces are found all over the Earth. Good examples are found in the northern High Plains of western North America. There are typically four planation surfaces in this area in Montana and Canada (Alden, 1932). Figure 2 shows the flat surface of the highest planation surface, the Cypress Hills of southeast Alberta and southwest Saskatch-

---

* Michael J. Oard, Bozeman, MT, mikeoard@bridgeband.com

Accepted for publication October 12, 2010

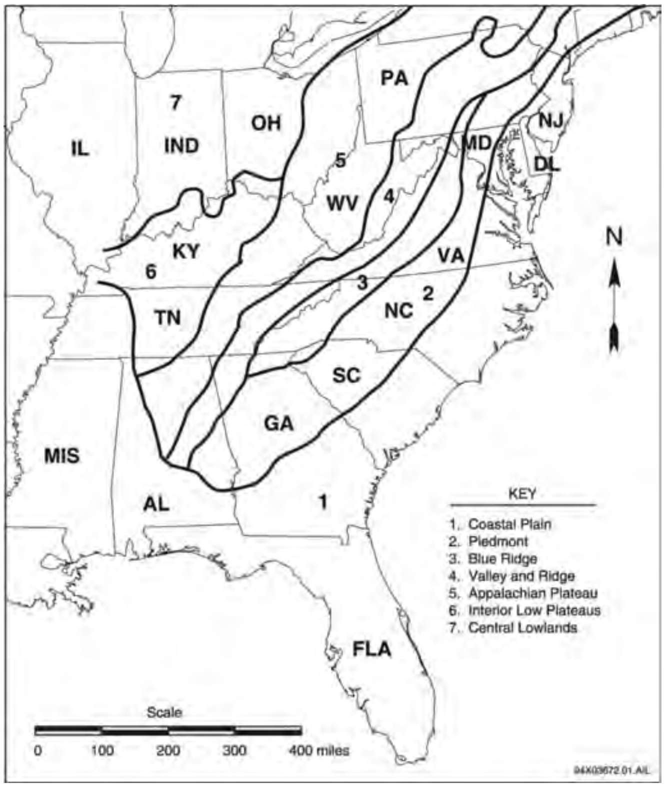


Figure 1. Map of the Appalachian provinces and the two provinces to the west. From Aadland et al. (1992).

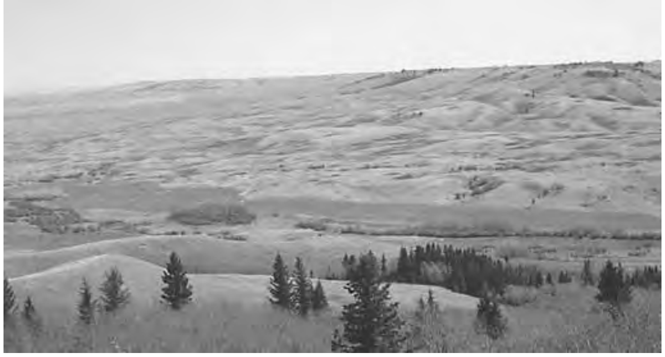


Figure 2. The flat top of the Cypress Hills planation surface near Reser Lake.

ewan (Oard and Klevberg, 1998). Before dissection, probably by glacial meltwater, this surface covered an area of about 2,500 km^2. Its western end stands about 300 m above the next planation surface, the Flaxville surface, and about 700 m above the rivers to the north and south. The top of the Cypress Hills surface is capped by an average 23-m-thick veneer of rounded quartzite cobbles and boulders (Figures 3 and 4). Quartzite is not exposed on the High Plains, and the rocks atop the Cypress Hills surface likely originated in the western Rocky Mountains of central and northern Idaho and western Montana, based on paleocurrent directional indicators, representing a total travel distance of over 500 km *across* the present continental divide (Oard et al., 2005). The minimum current velocity, based on the slope between the eastern Rocky Mountains and the top of the Cypress Hills, the size of the rocks, and the ubiquitous percussion marks on the rocks (Figure 5), is an incredible 30 m/sec at a minimum depth of 55 m (Klevberg and Oard, 1998). These numbers were based on the fact that percussion marks on hard quartzite rocks are ubiquitous, implying highly turbulent flow in which small- to medium-sized rocks are carried up into suspension for a short time and crash down into other quartzites. The minimum horizontal velocity and depth were calculated by estimating the fall velocity of a maximum size,

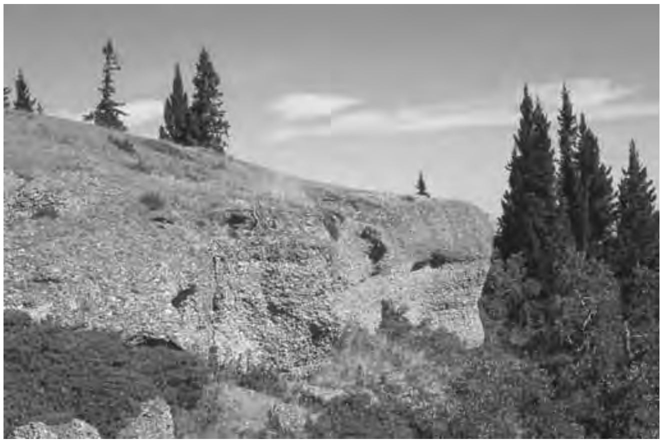


Figure 3. Quartzite conglomerate cap at Conglomerate Cliffs, western Cypress Hills.

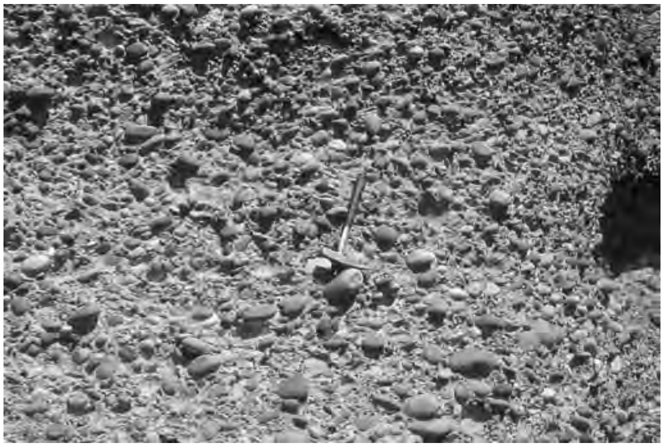


Figure 4. Close up of the quartzite conglomerate at Conglomerate Cliffs, western Cypress Hills.

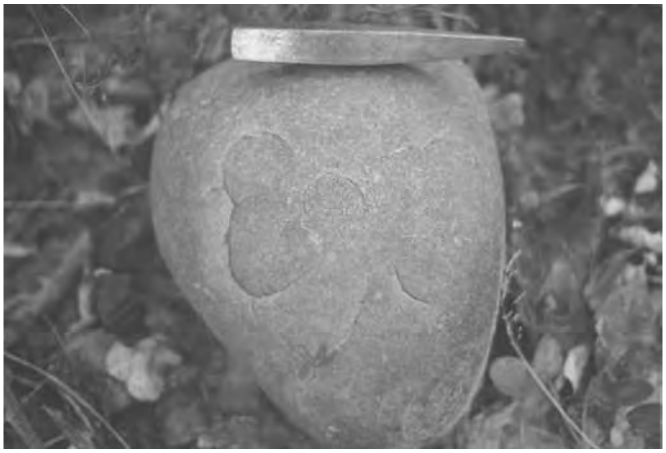


Figure 5. Large percussion marks on a quartzite boulder from the Cypress Hills gravel cap.

bullet-shaped rock of 15 centimeters diameter. The distribution of the gravels indicates these conditions existed in a sheet flow across the entire area.

In the Appalachians, there are three possible erosion surfaces. Due to their rolling morphology, they are not planation surfaces. From east to west, these include: (1) the Piedmont Province, (2) the accordant mountaintops of the Valley and Ridge Province, and (3) the Allegheny and Cumberland Plateaus. I include the Interior Low Plateaus Province to the west in the last.

The Piedmont Erosion Surface

The Piedmont Province starts just east of the Blue Ridge Mountains from the Hudson River in the north to Alabama in the south (Figure 6). It is 200 km at its widest point near the Virginia-North Carolina border. The Piedmont is bordered on the east by the Atlantic Coastal Plain Province, the boundary being the fall line. The Piedmont is relatively flat (Figure 7) with many erosional remnants called monadnocks (Figure 8). Stone Mountain, Georgia, is probably the best known (Figure 9) (Froede, 1995). It rises 240 m above the surrounding terrain. The Piedmont's elevation gradually rises westward to the Blue Ridge Mountains.

The highly deformed rocks of the Piedmont are predominantly igneous and metamorphic rocks with several distinct

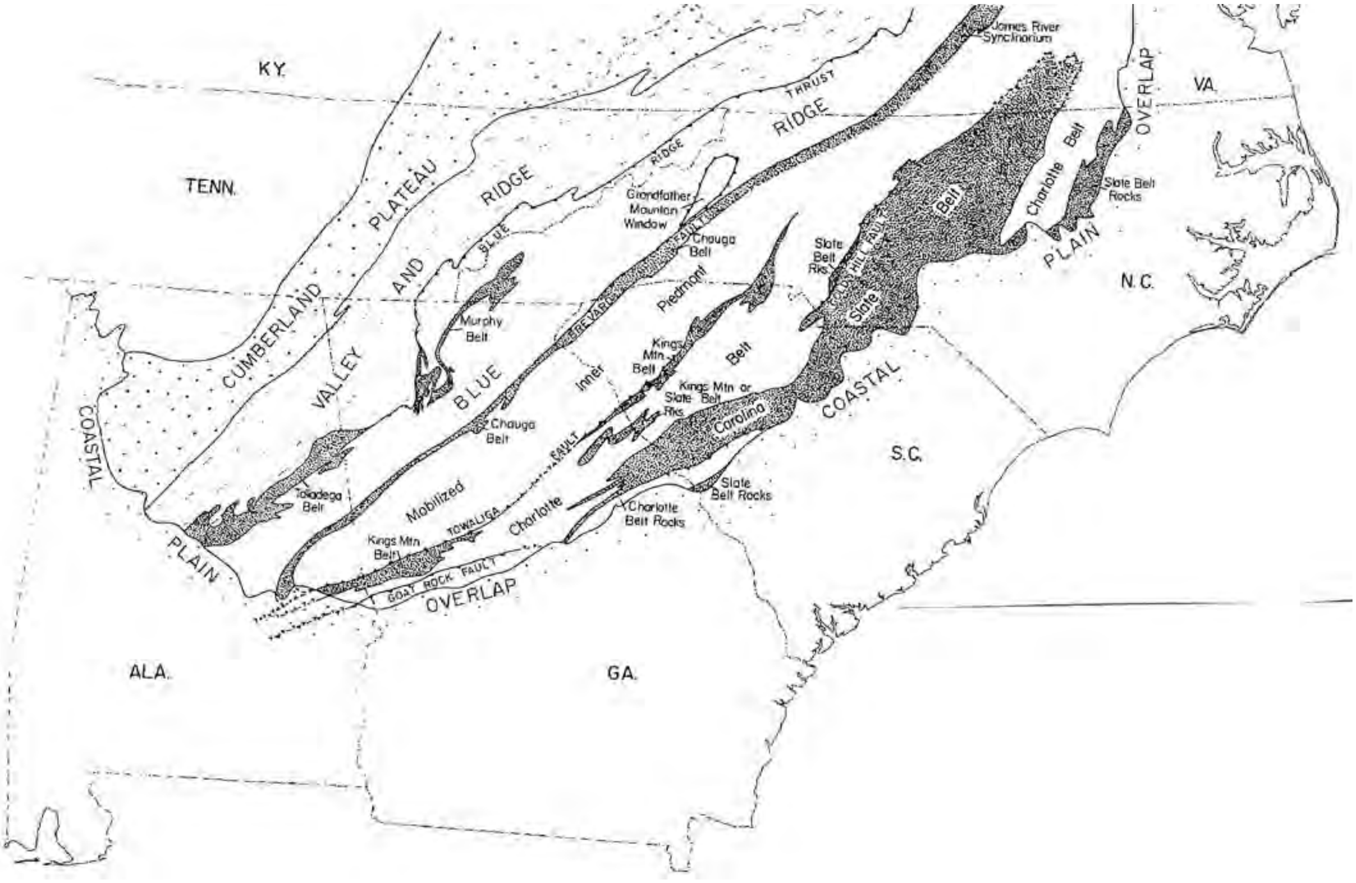


Figure 6. Map of the subprovinces (belts) on the Piedmont from Alabama to Virginia. After Hatcher (1972, p. 2,737).

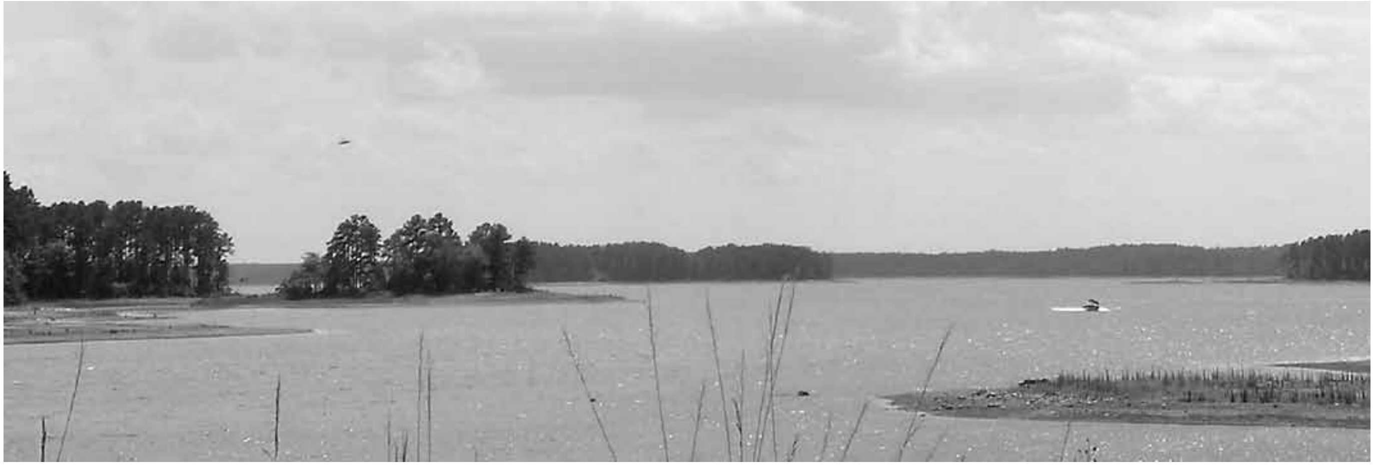


Figure 7. Lake on the Piedmont near Parkersville showing general flatness of the terrain.

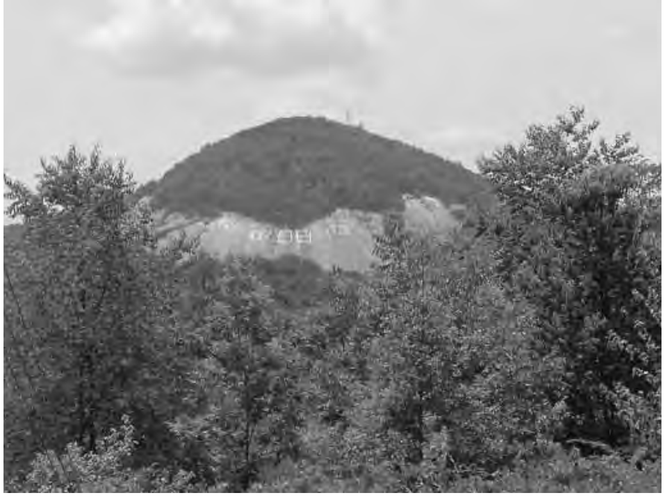


Figure 8. Monadnock on the Inner Piedmont close to Caesar's Head State Park, South Carolina.

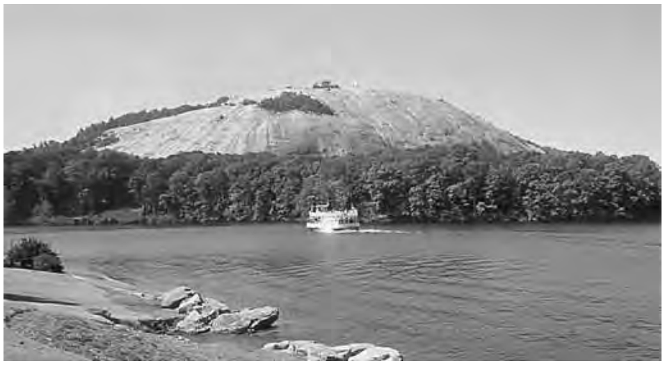


Figure 9. Stone Mountain, Georgia, monadnock. Photo courtesy of Carl Froede.

tectonic zones and lithologic belts parallel to the Blue Ridge Escarpment, such as the Brevard Fault zone, the Charlotte Belt, and the Carolina Slate Belt. Granitic bodies locally intrude the Piedmont. The type of rock varies widely; there are even some mantle-sourced rocks in spots (Farrar, 1985).

Nevertheless, the Piedmont has been planed fairly smooth across its entire area. The presence of rolling hills and monadnocks (see below) make it an erosional, rather than a planation, surface. Because of the lithology variations, erosion by modern processes over millions of years would have resulted in a more uneven surface, with hard rocks eroded less than soft rocks. By now, erosion over millions of years should have resulted in the harder rocks being mountains and the softer rocks being deep valleys. But both hard and soft rocks have been planed generally the same by erosion. Geomorphologist Nevin Fenneman (1938, p. 122) stated that the Blue Ridge Mountains and the Piedmont used to be called the "Older Appalachians," but the eastern part was planed:

> At a much later time the older belt became two physiographic provinces by the reduction of its seaward side of a relatively late peneplain (Piedmont province), while the higher belt on its western side (Blue Ridge province) was not destroyed.

Figure 10 is a shaded relief image of the central Appalachians around Ceasar's Head State Park at the Blue Ridge Escarpment, showing the rough, mountainous look of the Blue Ridge Province and the smoother look of the Piedmont to the southeast.

Because the Blue Ridge Escarpment between the two provinces shows evidence of significant headward erosion toward the west (see Oard, 2011), the scale of that event makes it likely that the Piedmont planation occurred at the same time. Fenneman's "peneplain" was the old name for an erosion surface; today, it is simply called an "erosion surface."

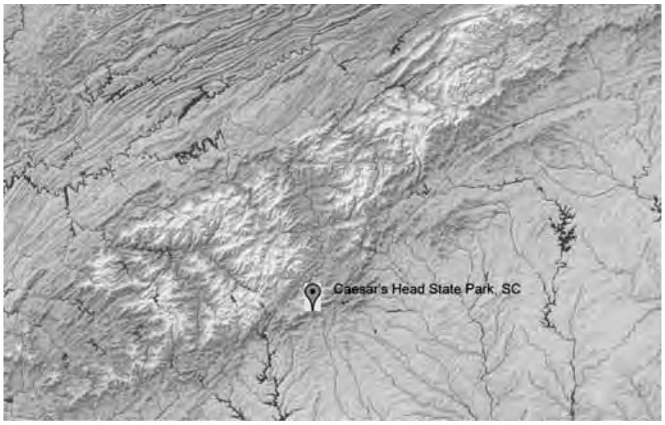


Figure 10. Shaded relief image of the central Appalachians around Caesar's Head State Park, South Carolina, at the Blue Ridge Escarpment showing the rough, mountainous look of the Blue Ridge Province and the smoother look of the Piedmont. The parallel ridges and valleys can also be seen to the northwest.

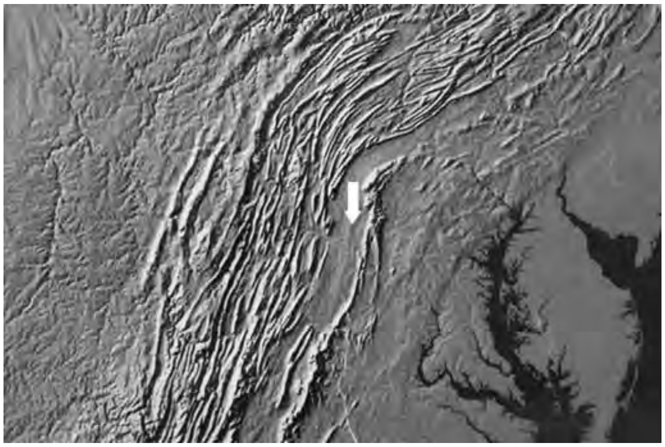


Figure 11. The distinctive geomorphology of the Appalachian Mountains in southern Pennsylvania, Maryland and eastern Virginia (from Landforms of the Conterminous United States). The Great Valley is shown by an arrow.

Are the Ridges in the Valley and Ridge Province an Erosion Surface?

The Valley and Ridge Province, on the opposite side of the Blue Ridge Mountains from the Piedmont (Figure 1), extends a distance of about 1,900 km from the St. Lawrence Lowland to Alabama (Fenneman, 1938; Thornbury, 1965). Its width varies from about 22 km along the New York-New Jersey state line to 125 km between Harrisburg and Williamsport, Pennsylvania. The province is thought to have formed by folding and thrusting toward the northwest of mostly early Paleozoic strata followed by erosion over millions of years. The ridges and valleys have a marked parallelism in a northeast-southwest direction (Figures 10 and 11). The Great Valley (see Oard, 2011) is usually considered the first valley, as it borders the Blue Ridge Mountains to the east.

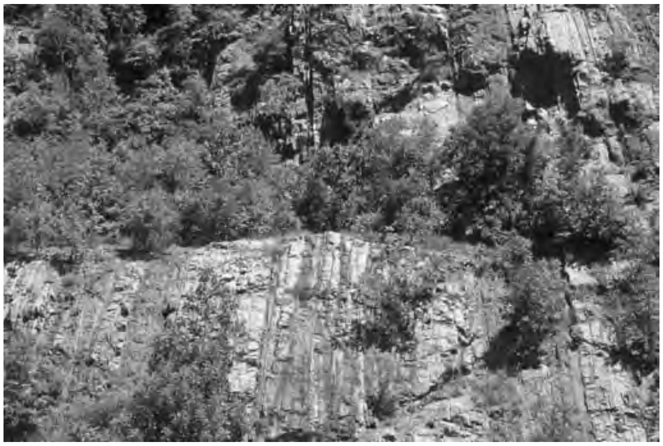


Figure 12a. Vertical strata in one of the water gaps on the Susquehanna River north of Harrisburg, Pennsylvania.

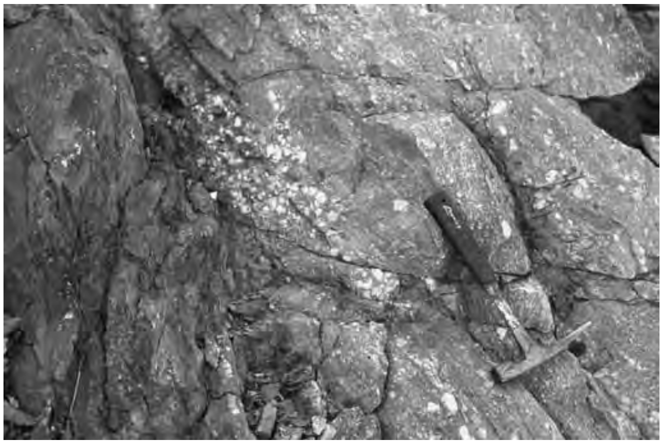


Figure 12b. Conglomerate in near vertical sedimentary rock in one of the water gaps on the Susquehanna River north of Harrisburg, Pennsylvania.

The crests of the ridges are generally hard sandstone or conglomerate (Figure 12a and b), and are moderately even or level, and of similar elevation, but rarely are any ridges wide enough to be topped by a flat surface. The valleys are mostly underlain by softer shales. Lithological differences probably explain the highs and lows. This is different from the erosion

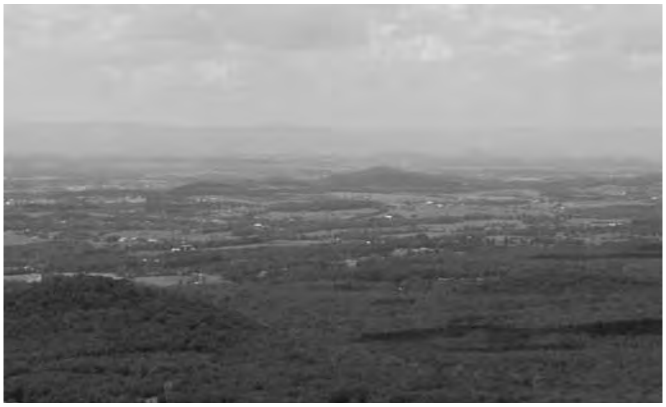


Figure 13. Monadnocks above flat floor of the Great Valley as seen to the northwest from Rocky Top Overlook, Shenandoah National Park, Virginia.

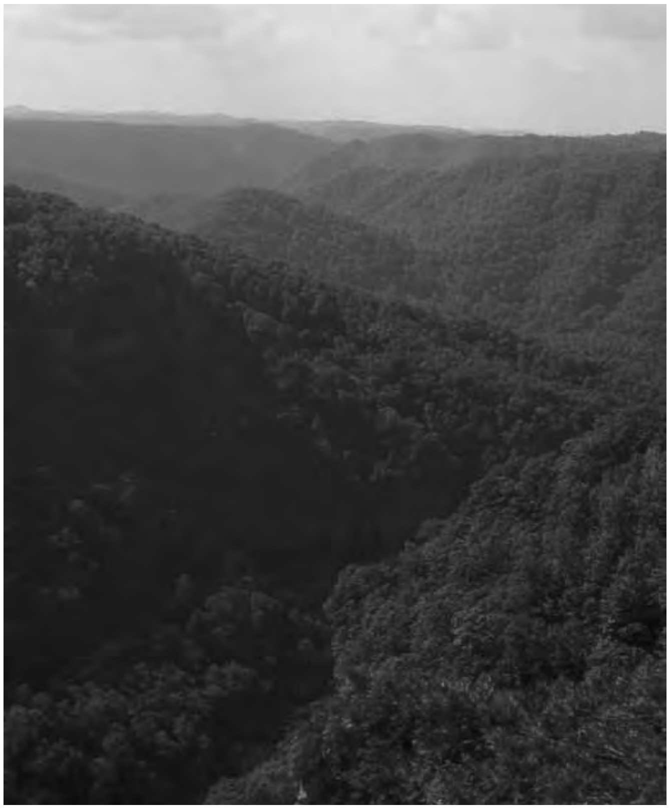


Figure 14. The dissected erosion surface on the border of Virginia and Kentucky at Breaks Interstate Park.

of the Piedmont, also with lithological differences but planed generally flat, while the Valley and Ridge were not. The level tops of many of the ridges suggested to some, such as William Morris Davis (Hack, 1989), that their crests represented an extensive erosion surface. It was named the "Schooley Peneplain" by William Morris Davis (Johnson, 1954, p. 489). A lower peneplain, developed in the valleys, was called the Harrisburg Peneplain. However, the accordant tops of the ridges need not represent a single regional erosion surface, but merely differential erosion of hard and soft folded rocks (Hack, 1989). Thornbury (1965, p. 127) suggested:

> We must, of course, always keep in mind the possibility that the topography of the Ridge and Valley province can be interpreted reasonably without resort to erosion cycles and peneplains.

Therefore, I will not treat the accordant tops of the Valley and Ridge Province as a regional erosion surface.

However, the bottom of the Great Valley likely is a linear erosion surface, since in many areas the valley floor is flat and has truncated sedimentary rocks of different hardness. Also, monadnocks occur in the Great Valley (Figure 13). This erosion surface can be equated with the Harrisburg peneplain of Davis's cycle of erosion.

Erosion Surfaces West of the Valley and Ridge Province

Immediately west of the Valley and Ridge Province is the Appalachian Plateau Province, which stretches from northwestern New York to northeastern Alabama (Fenneman, 1938, pp. 279–342). It attains a maximum width of 320 km in the Ohio-Pennsylvania-West Virginia area (Thornbury, 1965) and occupies more than 66,000 km^2. The Appalachian Plateau consists of the Allegheny Plateau in the north and the Cumberland Plateau in the south. The boundary between the two is rather arbitrary. Most of the Appalachian Plateau is significantly dissected by streams, and thus different from many plateaus found in the western United States. Briggs (1999) subdivided this area into miniprovinces.

The rocks below the Appalachian Plateau are relatively undeformed, except in the east (Dennison, 1976). The highest point of the plateau is along the eastern border of West Virginia and Kentucky, where the plateau edge exceeds 1,200 m (Figure 14). Although the altitude of the plateau varies, it is generally higher than the Valley and Ridge Province and the Low Plateaus Province to the west and is bounded on most sides by outfacing escarpments. One exception is the northwest part of the plateau, from a point east of Columbus to near Cleveland, Ohio. This could have been caused by glaciation, which reached the northern Allegheny Plateau (Oard, 2004), as evidenced by glacial debris, and the loss of the escarpment in the northwestern plateau.

The Appalachian Plateau Province is considerably dissected by channelized erosion, the type that forms canyons and valleys (Figure 15). It is so dissected along its eastern margin that the topography is designated as mountainous—the Allegheny Mountains or Allegheny Front. Relief in the Allegheny Moun-

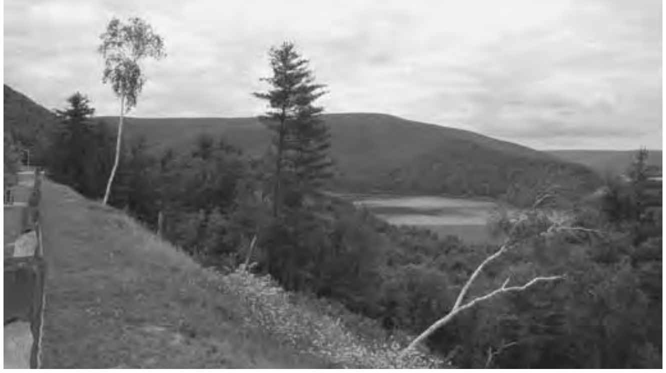


Figure 15. View southwest of an erosional remnant of the Allegheny Plateau showing considerable dissection around it (view southwest from Welcome Center Rest Stop, I-15, north central Pennsylvania).

tains reaches about 300 m, but it is 600 m in the Cumberland Mountains along the eastern Cumberland Plateau called the Cumberland Front (Figures 16 and 17). The New River deeply incises the Appalachian Plateau (Figure 18). Although localized erosion cuts the Appalachian Plateau Province, the plateau once was a large erosion surface (Figure 19). The Allegheny Plateau, the northern Appalachian Plateau, is rolling and has also been more severely eroded (Figures 20 to 22) than the Cumberland Plateau, which is quite flat and less dissected (Figures 23 and 24).

In the western part of the Appalachian Plateau Province, there is a bench about 100 m above the major river valleys (Figure 25) cut into hard rock. It is considered a strath terrace and named the Parker Strath in many places. A strath terrace

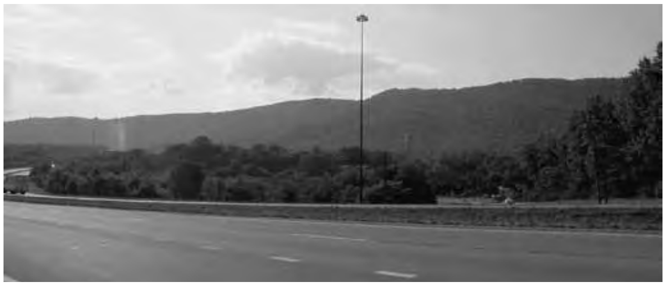
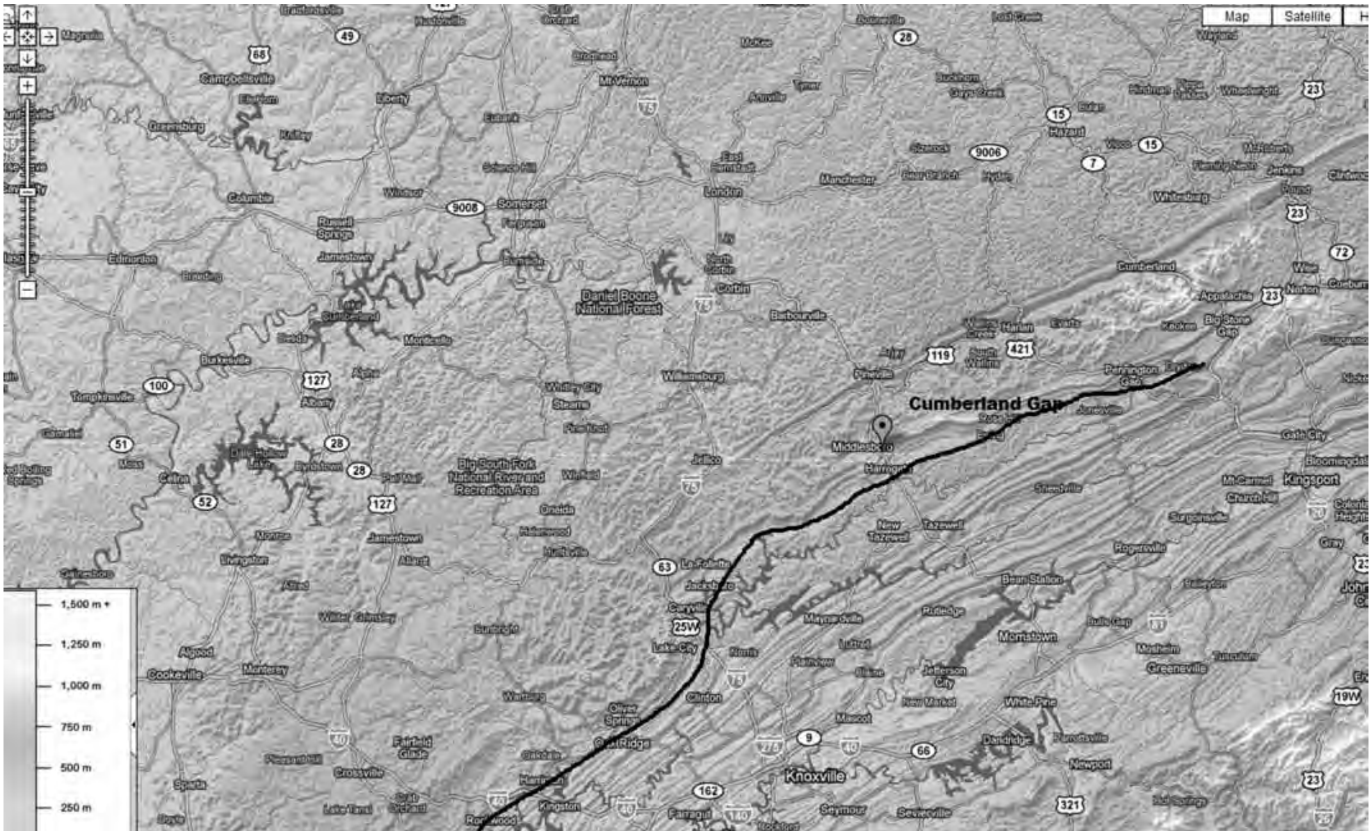


Figure 16 *(left)*. Cumberland Front at the edge of the Cumberland Mountains, looking west from I-40 in Tennessee.

Figure 17 *(below)*. Google map image of Cumberland Front (solid line). The Cumberland Front is the boundary between the subdued relief of the Cumberland Plateau to the northwest and the Valley and Ridge Province to the southeast. The Blue Ridge Province can be seen in the lower, right corner.



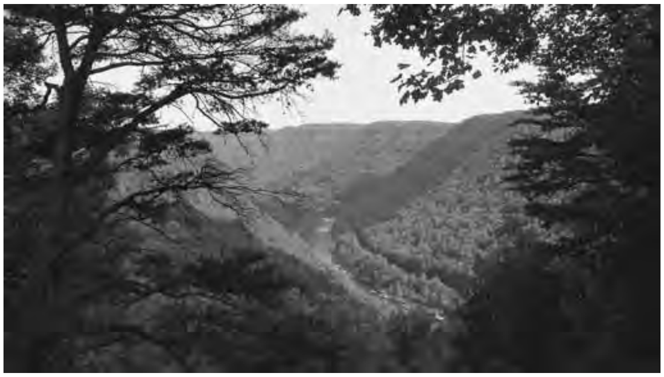


Figure 18. New River Gorge near the New River Bridge, West Virginia.

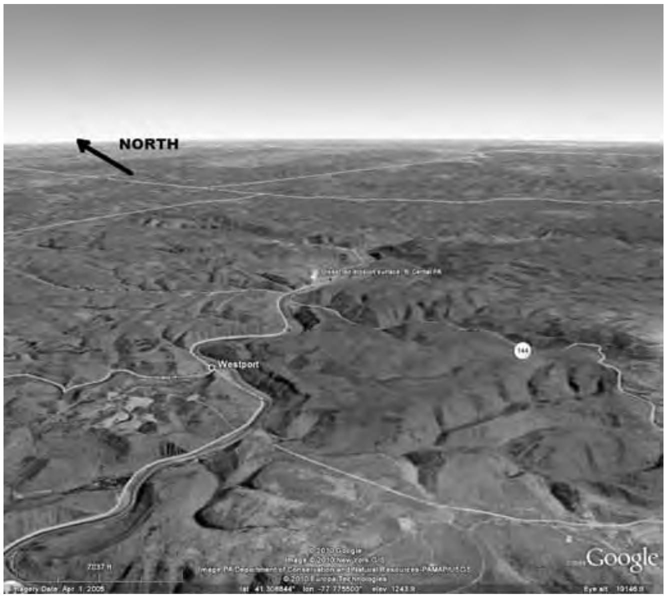

NORTH
Westport
144
Google
©2010 Google
Image © 2010 New York GIS
Image PA Department of Conservation and Natural Resources-PAMAP/USGS
©2010 Europa Technologies

Figure 19. Dissected erosion surface, north central Pennsylvania. Vertical exaggeration = 1.5.

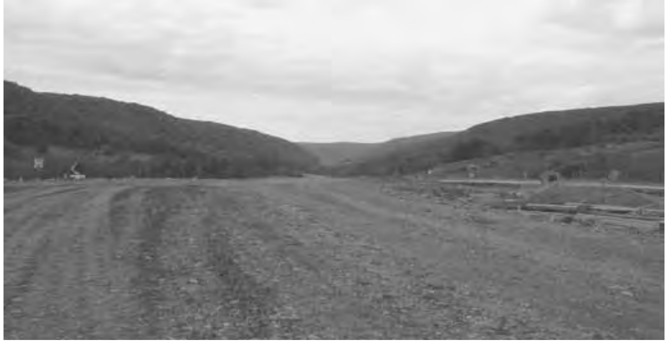


Figure 20. Top of rolling, dissected erosion surface of the Allegheny Plateau north central Pennsylvania.

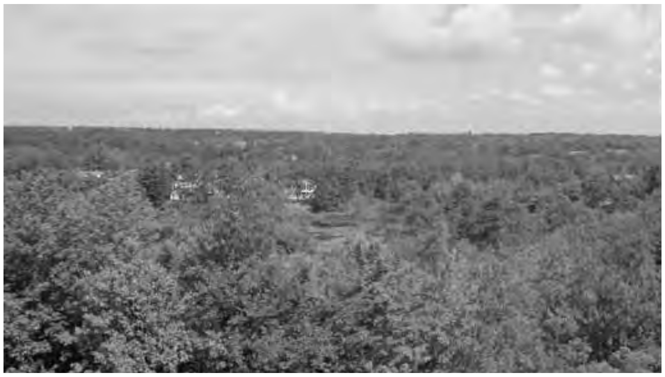


Figure 21. Top of fairly flat erosion surface of the Allegheny Plateau east central Pennsylvania.

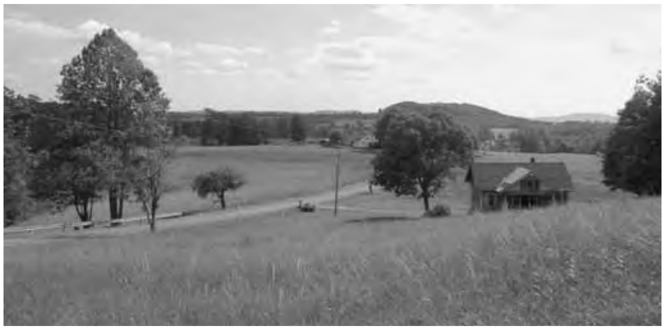


Figure 22. Top of rolling erosion surface of the Allegheny Plateau, southeast West Virginia.

is a narrow erosion surface formed during dissection of the valleys and gorges.

To the west of the Appalachian Plateau Province lies the Interior Low Plateaus Province (Fenneman, 1938, pp. 411–448; Thornbury, 1965, pp. 185–211). The Interior Low Plateaus Province represents a lower erosion surface, called the Lexington Plain (Figure 26). Fairly flat and rolling, it is more a plain than a plateau (Figures 27 to 29). Its eastern boundary is the escarpment up to the Appalachian Plateau in eastern Kentucky and Tennessee (Figure 30). It extends north to the edge of Ice Age glaciation and west into western Kentucky and Tennessee (Figure 1). Gravels from the Appalachian Mountains cover parts of this surface, especially in western Kentucky (see below). The Lexington Plain is less severely dissected than the Appalachian Plateau Province.

Erosional Remnants

Erosional remnants are common on Appalachian erosion surfaces. They are typically hills or even mountains that survived

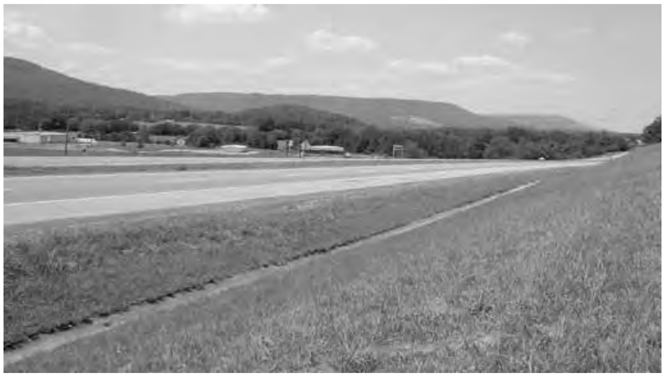


Figure 23. View northwest of the top of the nearly flat erosion surface of the Cumberland Plateau, Sequatchie Valley, southeast Tennessee.

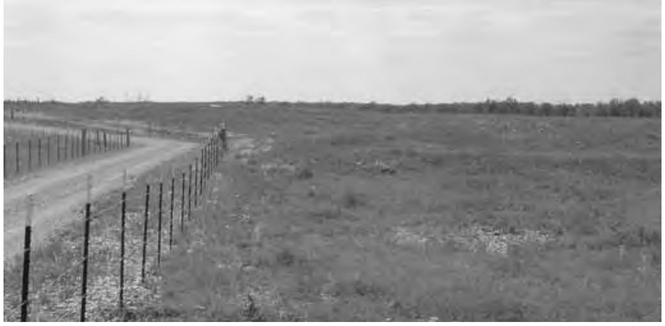


Figure 24. Nearly flat erosion surface of the Cumberland Plateau, southeast Tennessee.

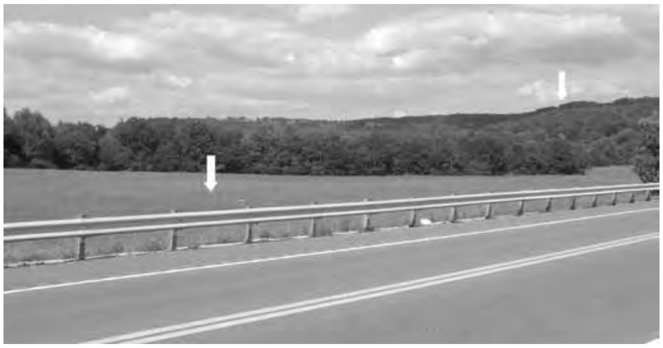


Figure 25. Rolling strath terrace (left arrow) west of the nearly flat erosion surface of the Cumberland Plateau (right arrow).

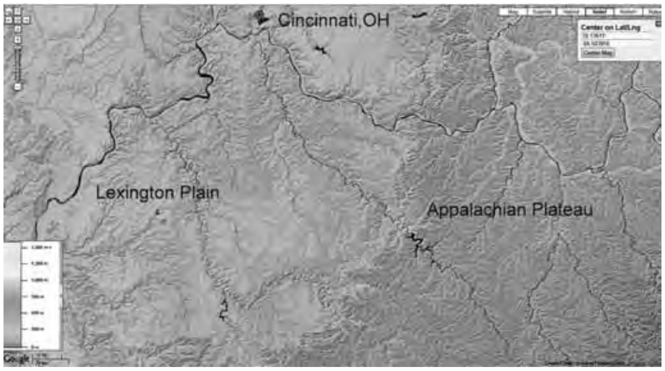


Figure 26. Shaded relief map of Cincinnati, Ohio, region and south, showing the Lexington Plain and the higher Appalachian Plateau with a sharp boundary (escarpment) between them. From shaded-relief.com.

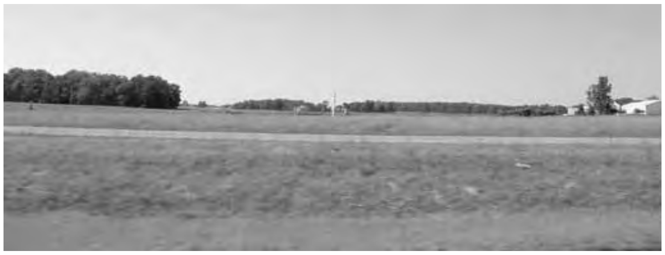


Figure 27. Erosion surface of the Interior Low Plateaus Province northeast of Cincinnati, Ohio.

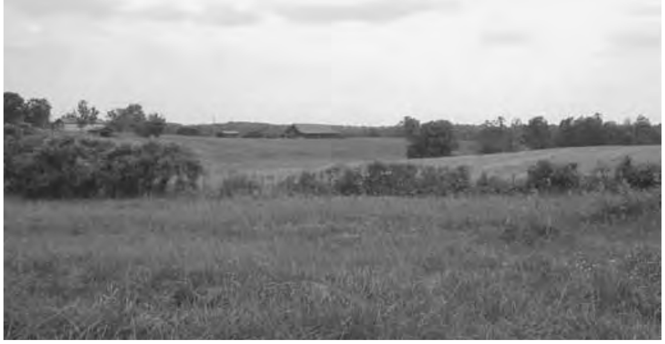


Figure 28. Erosion surface of the Interior Low Plateaus Province, south central Kentucky.

erosion, although reduced in elevation (Small, 1978). Any proposed erosional mechanism must account for these remnants. Most are inselbergs, defined as "a prominent isolated residual knob, hill, or small *mountain of circumdenudation*, usually smoothed and rounded, rising abruptly from and surrounded by an extensive lowland erosion surface" (Neuendorf et al., 2005, p. 328, emphasis his). *Inselberg* is a German word meaning a hill or an island jutting up from a flat sea, or more simply an "island mountain" (Faniran, 1974, p. 151). They are associated with hot, dry environments but occur in many different climates.

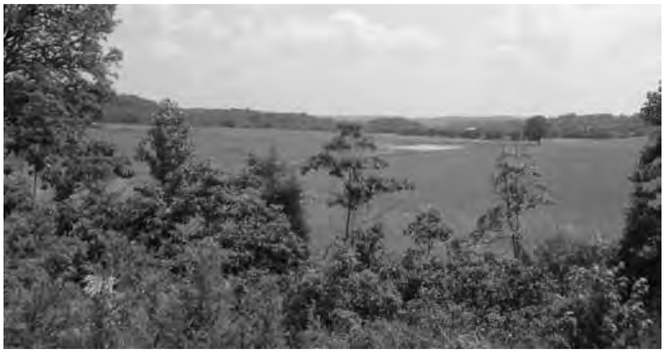


Figure 29. Erosion surface of the Interior Low Plateaus Province, western Kentucky.

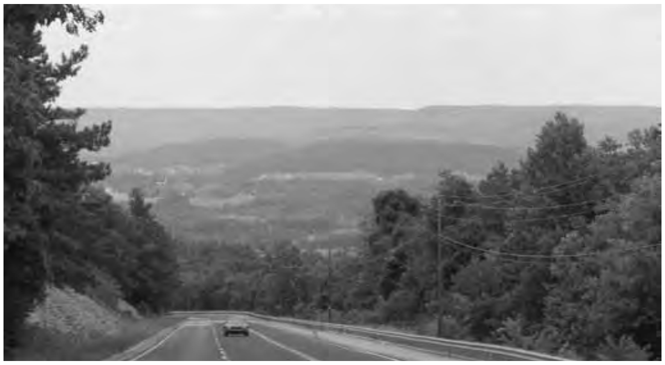


Figure 30. The western escarpment of the Cumberland Plateau looking northwest. The flat surface in the background is the continuation of the Cumberland Plateau that wraps around the valley below.

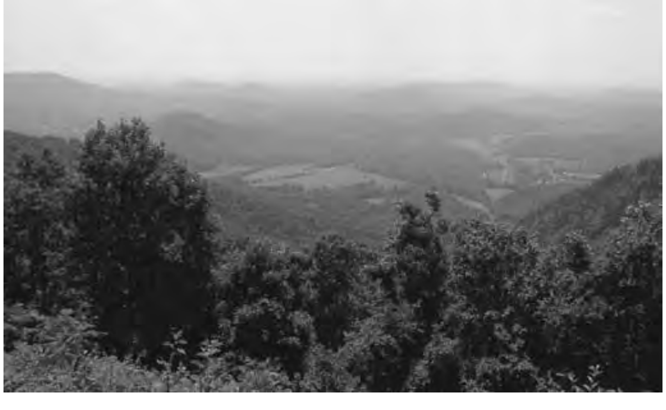


Figure 31. Monadnocks on the Inner Piedmont as seen from High Piney Spur, Blue Ridge Parkway, looking east.

A synonym often used in the eastern United States is "monadnock"; the same as the African "bornhardt." Stone Mountain, Georgia, is a famous monadnock on the Piedmont (Figure 9), but only one of hundreds (Figure 31, and see Figure 8). The distribution of monadnocks on the Piedmont approaching the Blue Ridge Mountains indicates a northwest erosional retreat of the Blue Ridge Escarpment (Hack, 1989).

The origin of inselbergs is one of many puzzles in geomorphology (Twidale, 1982) and has generated considerable controversy for many years. Their mere existence, towering over planation and erosion surfaces, is problematic, but that is multiplied by their supposed duration from tens to over 100 million years (Oard, 2008). Aspects of structure and lithology seem to control their development, but those correlations appear weak (Twidale and Bourne, 1998; Römer, 2005), following King's (1966) observation of a lack of any structural control on many inselbergs. Some researchers have noticed a correlation between fracture patterns in inselbergs and the surrounding land. Inselbergs seem to be less fractured or jointed (Twidale, 1981; Twidale and Bourne, 1998), but the question is far from settled (Römer, 2005). Thomas (1978, p. 3, emphasis his) stated:

> Enquiry into the origins and development of the prominent and generally isolated hills described as *inselbergs* continues to arouse controversy after many decades of research.

Long-Distance Transport of Resistant Rocks

Resistant rocks eroded from the Appalachians have been transported long distances out onto the surrounding lowlands. Remnants of what was probably once a widespread gravel deposit are often found at the highest elevations and have been given different names at different locations.

That west of the Appalachian Mountains is generally called the Lafayette Gravel. It is found in scattered upland locations over a wide area east of the Mississippi River valley, from the Ohio River in the north into the southern states (Autin et al., 1991; Ehlers, 1996; Thornbury, 1965). Its original extent is unclear since so much of it has been eroded (Bresnahan and Van Arsdale, 2004). The larger clasts are typically iron-stained and composed mostly of brown chert (Figures 32 and 33), a hard silicate. Figure 34 is a close-up view of the Lafayette Gravel in Figure 33. Quartzite, sandstone, and vein quartz are minor constituents of this gravel. Vein quartz forms by hydrothermal deposition in cracks and is generally white. The gravels are rounded to subrounded and up to 10 cm in diameter. A significant amount of finer-grained sediment is mixed in with the gravel.

It appears that a regional gravel sheet once covered the Appalachian plateaus and extended across much of the area west of the Appalachians—in some places even beyond the Mississippi River (Autin et al., 1991; Ehlers, 1996; Potter, 1955b; Thornbury, 1965). The Lafayette Gravel shows paleocurrent directions toward the northwest. Potter (1955a, 1955b) noted that the sand and some of the larger clasts originated from the Blue Ridge Mountains, while others are local. It is interesting

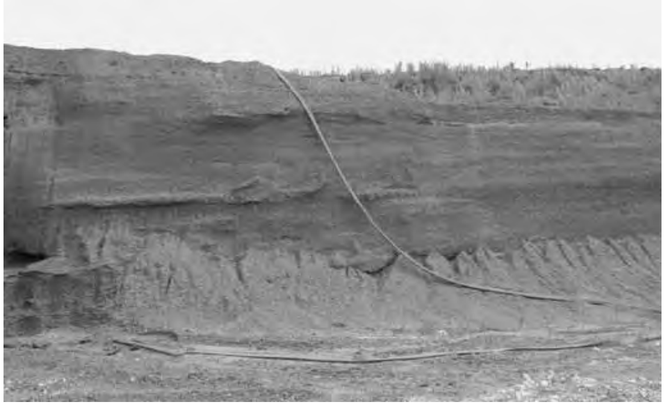


Figure 32. The Lafayette Gravel in the Milby pit, western Kentucky. Except for a surficial layer, the in situ gravel extends from top to bottom of the pit with the lower gravel obscured with talus.

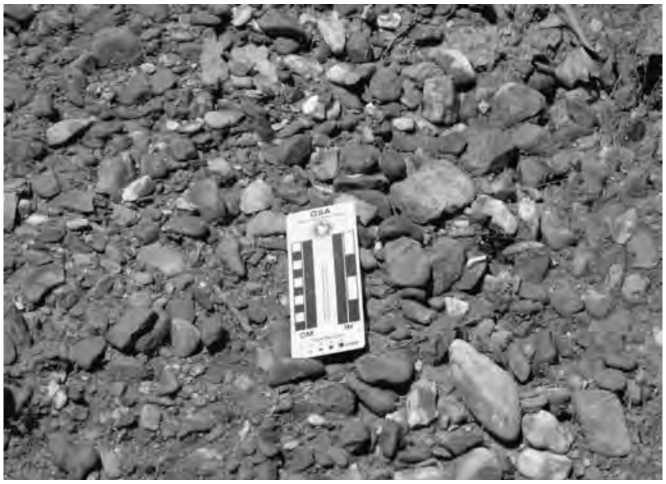


Figure 34. Close up of the Lafayette Gravel shown in Figure 33.

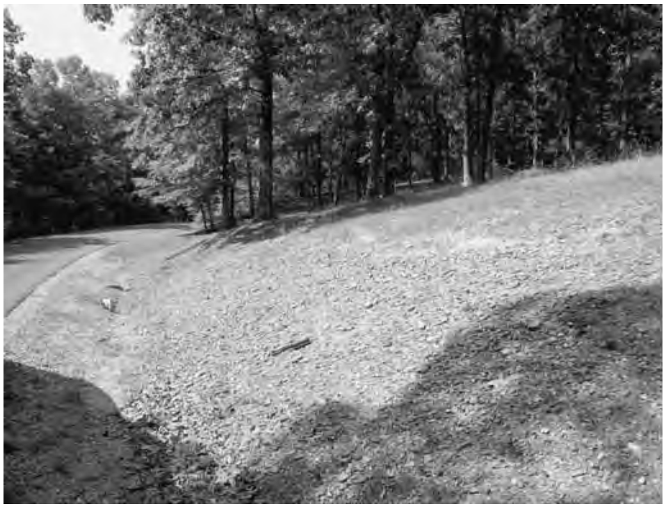


Figure 33. The Lafayette Gravel along a road in western Kentucky.

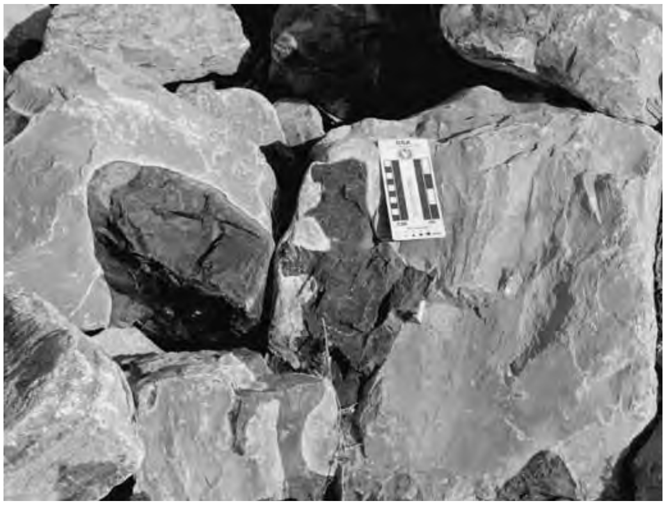


Figure 35. Black chert within the limestone of western Kentucky, which is a different color than the overwhelmingly tan cherts of the Lafayette Gravel.

that the chert within the limestones of western Kentucky is black (Figure 35) while the Lafayette Gravel is tan, supporting the allochthonous origin of the Lafayette Gravel. The distance from the Mississippi River in western Kentucky eastward to the Blue Ridge Mountains is about 800 km. Thus, it is likely that a widespread sheet of gravel and sand was deposited over a low slope, probably during planing. After its deposition, the area was dissected by channelized erosion, eroding and redepositing some of the gravel.

Resistant gravels were also deposited east of the Appalachian Mountains, and surviving remnants cap the highest terrain. A sheetlike gravel around 7 to 9 m thick covers approximately 1,530 km^2 of the coastal plain of southern Maryland (Schlee, 1957). There are also some isolated upland gravels on the Virginia coastal plain. Upland surfaces near the coast in northeastern Maryland, Delaware, southeastern Pennsylvania, and New Jersey are also covered by the Brandywine and Bryn Mawr Gravels (Owens, 1999; Owens and Minard, 1979; Pazzaglia, 1993; Stose, 1928).

Sand with quartzite pebbles has also been found as far south of the Appalachian Mountains as Florida (Froede, 2006, 2009), extending down to the northern Keys, where they are found in drill holes in the subsurface. Such quartzites are widespread and contain clasts that are over 7.5 cm in their long axis. The evidence shows these Florida quartzites were derived from the Appalachians, more than 1,000 km away.

Uniformitarian Hypotheses on Formation of Erosion Surfaces

In the 1800s, many geologists believed that erosion and planation surfaces were caused by marine planation during sea level rises. Then in about 1900, William Morris Davis developed the "cycle of erosion" or the "geographical cycle" for the formation of erosion surfaces called peneplains. Davis and his cycle of erosion exerted considerable influence upon geomorphology that still continues, though diminished, today.

The Rise and Fall of Davis's "Cycle of Erosion"

Davis was born into a liberal Quaker home, but the Quakers influenced him little, since his father was expelled from the church. Davis's religious views ended up as mainly moral sentiments, which eventually led him into unitarianism and an unshakeable faith in the hypothesis of evolution. His real interest was geology. He joined the geology department at Harvard University despite having *no* field experience (Chorley et al., 1973). After an inauspicious start, he was given a strong hint by the president of Harvard University that he should look for employment elsewhere. He might have disappeared into obscurity, except for one lucky break.

In 1883, he conducted a geological survey of the route for the Northern Pacific Railway in Montana. Davis described his summer on the High Plains as a lifesaver, for it was there that he conceived the idea for his cycle of erosion (Chorley et al., 1973, p. 135; Crickmay, 1974, p. 171). Chorley et al. (1973, p. 160) described his revelation:

> Although Davis constantly acknowledged his debt to such predecessors as Powell, Jukes, Dutton and Gilbert, in later life he came to refer to his first notion of the cycle of erosion, while working on the Northern Pacific Railroad Survey in Montana in 1883, as rather like the blinding flash of understanding experienced by a prophet in the wilderness.

Davis recognized the enormous denudation of the plains of Montana, as indicated by igneous mesas and dikes in bold relief (Chorley et al., 1973, p. 136). Davis imagined that the many erosion and planation surfaces there were caused by ancient rivers and streams sweeping back and forth, smoothing the land over millions of years. He took special note of the comparative smoothness of the plain between Fort Benton and Great Falls, Montana (Chorley et al., 1973, pp. 162–163). This plain is the eastern Fairfield Bench (Figures 36 and 37). Back at Harvard the next fall, Davis developed his theory and applied it to erosion surfaces of the Appalachians. From then on, he published extensively on this subject into the early 1900s.

Davis' idea was strongly influenced by the theory of evolution (Flemal, 1971). Summerfield (1991, p. 457) summarized its influence on Davis' views:

> The model of landscape evolution usually known as the cycle of erosion was developed by W. M. Davis between 1884 and 1899 and owed much to the evolutionary thinking that had permeated both the natural and social sciences in Britain and North America during the latter half of the nineteenth century.

Davis believed that, just like life, landscapes evolved through progressive stages, each exhibiting characteristic landforms. Davis applied the popular analogy of age to landscapes. They initially started in their *youth*, with the tectonic uplift of a level surface; progressed to *maturity*, with strong dissection by rivers and streams; and finally reached *old age*, where the land is finally subdued to a low relief *peneplain* near sea level (Johnson, 1954) and ready for another cycle.

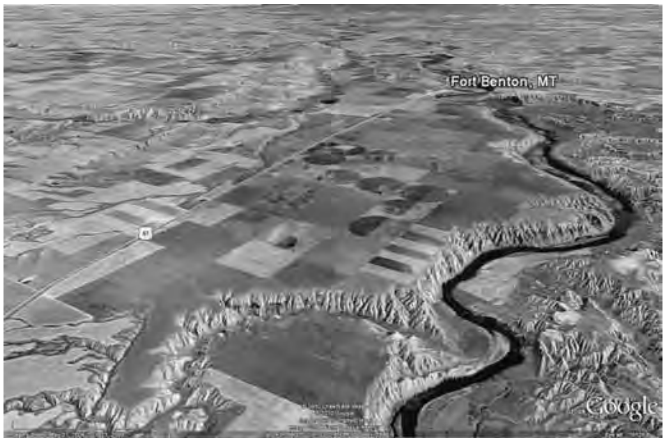


Figure 36. Google Earth image showing the eastern Fairfield Bench. Note that the bench is mildly dissected with the deepest dissection caused by the Missouri River on right. Vertical exaggeration = 2; north toward top right hand corner.

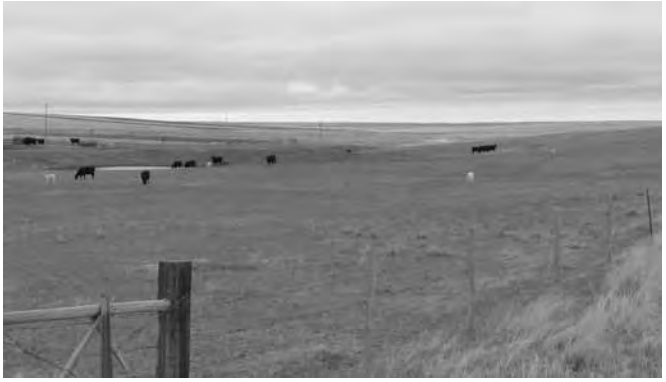


Figure 37. The rolling eastern Fairfield bench, northeast of Great Falls, Montana. It was this erosion surface that inspired William Morris Davis to deduce his "cycle of erosion" or "geographic cycle."

But this idea is fraught with difficulties. During the early 1900s, despite its popularity, geologists slowly became skeptical. By the 1950s, the hypothesis was widely rejected. Summerfield (1991, p. 460) considered the hypothesis vague, qualitative, and based on a number of unreasonable assumptions. Other than observations of erosion surfaces over large parts of the earth, it was simply a collection of intuitive deductions and not based on fieldwork:

> While stressing the Victorian character of much of Davis' work it is only fair to note that he departed from the characteristic standards of much nineteenth-century work in the natural sciences in three important particulars: his lack of detailed field measurements, his unconcern with details of processes prompting change and the entirely qualitative nature of his methods (Chorley et al., 1973, p. 194).

Davis's deductions were not necessarily wrong; it was his failure to test them in the field that was problematic. Davis could not demonstrate the transitions between stages by detailed observations and experimentation. When challenged on that point, he simply pointed out the many flat surfaces of Earth's landscape as evidence for his hypothesis (Johnson, 1954; Chorley et al., 1973, pp. 242, 243)—a logical fallacy called *begging the question*, a type of circular reasoning.

Peneplains are rolling erosion surfaces. To form a flat planation surface would take more time than was available, even on the geologic timescale. Some geologists pointed this out (Crickmay, 1933; 1974, p. 173; Hart, 1986, p. 21). Ollier (1991, p. 200) claimed that just one-half of Davis's cycle took the last half of the Phanerozoic, or 250 million years, in the highlands of southeast Australia! However, many of Davis's peneplains, including the ones in Montana, are actually quite flat (Crickmay, 1974, p. 174). They should more properly be called planation surfaces and not peneplains; and according to Davis's hypothesis, they should not have formed at all.

Another major problem is that streams and rivers dissect a surface; they do not plane it. They destroy already-existing planation and erosion surfaces. So, Davis's theory is defeated by uniformitarianism itself. Planation and erosion surfaces that are common worldwide formed in the past by some large-scale unique event (Oard, 2008).

Davis also failed to provide any examples of the ending stage: a peneplain at sea level (Flemal, 1971; Chorley et al., 1973, Phillips, 2002). Davis once suggested the low altitude plains of the Ob and Irtysh Rivers of western Siberia as a modern example of a peneplain, but these plains are not erosion surfaces but surfaces of deposition (Crickmay, 1972, p. 174). Thus, the final stage of the cycle of erosion is *not* observed in the landscape today.

> The scheme of the cycle is not meant to include any actual examples at all, because it is by intention a scheme of the imagination and not a matter of observation (Johnson, 1954, p. 281).

Many more problems with the cycle of erosion can be pointed out.

The Weathering Hypothesis

A number of other hypotheses have been proposed in place of the cycle of erosion, but none seem to have fared well. These hypotheses include Walther Penck's erosion during slow tectonics, Lester King's parallel retreat of slopes, John Hack's dynamic equilibrium, C. H. Crickmay's lateral planation and unequal erosion, and the weathering hypothesis developed in the early to mid-1900s. The weathering hypothesis is the most popular idea today and seems to have survived among geomorphologists because it fills a theoretical void (Thomas, 1994).

The weathering hypothesis was first proposed by Falconer in 1911 (Small, 1978, p. 295). It was especially emphasized and developed by Wayland in the early 1930s and by Bailey Willis (1936) in his study of East African plateaus and rift valleys. It was advanced by Büdel during the third quarter of the twentieth century, primarily to account for tropical erosion and planation surfaces (Ahnert, 1998, p. 222).

In the hypothesis, erosion or planation surfaces form by two processes. First, a landscape is chemically weathered downward with time. The boundary between the weathered debris and unweathered rock is called the *weathering front*. Most weathering is accomplished by ubiquitous shallow groundwater (Baker and Twidale, 1991, p. 81). Second, the weathered debris is removed by sheet wash, stream erosion, or other mechanisms. Both stages can occur simultaneously. The mechanism is especially affective in the humid tropics, where weathering is sometimes observed deeper than 100 m. The resulting landform is called an etchplain if planar, and an etchsurface if not.

However, there are many problems with the weathering hypothesis. Most telling, weathering does not form a planation surface and would form an erosion surface only with great difficulty. Factors driving weathering rate vary spatially (Birkland, 1984; Hall, 1988), as does erosion. Lithology and drainage patterns are especially relevant to the weathering rate (Summerfield, 1991). Therefore, the weathering front should be *rough and not planar*. Twidale (2004, p. 160) stated: "Weaknesses in the country rock are exploited by moisture and the weathering front is frequently irregular in detail: a topography is developed." How could an exceptionally flat surface over a large area form by such irregular weathering?

Contrary to the hypothesis, weathering is more likely to *destroy* a planation surface than to create one. Hall (1988, p. 12, emphasis his) admitted:

> It is far from simple to determine what weathering process acted to cause the formation of any given landform. The type of weathering *currently* active may be in the process of destroying, rather than forming, that landform.

Although Hall was thinking about landforms in general, planation surfaces would fall under his generalization.

Even if the weathering occurred on a planar surface, there is the problem of stripping the debris away just as evenly (Bishop, 1966). Many planation surfaces are bare rock, especially in Africa. King (1975, p. 309) questioned how deep weathering products could be removed from a flat surface, leaving no weathered material behind. Taylor and Howard (1998) claim that tectonics causes the removal of the weathering products that collect during a stillstand. But, how would uplift of a planation surface erode the weathered material to bare rock? Even uplift would not stop the dissection of a surface.

Fourth, it has also been observed that planation surfaces sometimes cut across *both* weathered and unweathered surfaces, indicating that planation is independent of weathering (Bishop, 1966, p. 149). Pugh (1966, p. 125) stated: "The perfection of plains cut without distinction across weathered and unweathered material implies considerable efficiency of erosional processes." It also indicates that the denuding mechanism was independent of weathering—the heart of the hypothesis.

Fifth, how would the weathering hypothesis account for all the rounded rocks on top of some planation and erosion surfaces, especially those obviously transported long distances? The weathering hypothesis cannot account for any of these, whether on the high plains of Montana or the rolling plains and plateaus of Kentucky. Table I presents a summary of these difficulties.

All Geomorphological Hypotheses Fail

Proponents of the weathering hypothesis can take comfort in one thing: no other secular geomorphological hypothesis explains the observations either. They all have numerous weaknesses, as noted by conventional old-age geologists (Crickmay 1974, p. 192, brackets mine):

> The difficulty that now confronts the student [all who study geomorphology] is that, though there are plenty of hypotheses of geomorphic evolution, there is not one that would not be rejected by any majority vote for all competent minds. This situation is in itself remarkable in a respectable department of science in the latter half of the 20th Century.

Table I. Some problems with the weathering hypothesis for the formation of planation surfaces
Weathering causes a rough surface, not a planation surface.
Weathering will destroy an already existing planation surface.
Weathered debris must be stripped from the area.
Planation surfaces cut across both unweathered and weathered rock.
Cannot account for exotic rounded rocks with percussion marks.

This situation is remarkable indeed! Crickmay went on to state how many inspiring ideas led into error with time.

> A century and a half of literature bearing on scenery and its meaning shows primarily the inspired innovations that carried understanding forward; followed in every case by diversion from sound thinking into inaccuracy and error (Crickmay, 1974, p. 201).

Thomas and Summerfield (1987, pp. 936–937, emphasis added) expressed the same sentiment over the failure to explain planation surfaces:

> Understanding the long-term denudation of landscapes remains speculative, despite attempts to find bridges between theories and the evidence which supports them. The existence of planation surfaces is asserted by a host of writers, yet few attempt any serious explanation of their development ... It is perplexing that after a century of argument and observation of the continents, *no generally accepted mechanism for planation has been forthcoming*.

Small (1978, p. 13) corroborated, despairing of geomorphology's insoluble puzzles:

> Any serious student of geomorphology will quickly realize what is actually known with certainty about landforms and their origin is surprisingly small, despite the vast amount of research, testified to by innumerable books, articles and reports, which has been done during the last fifty or so years.

Davis confidently predicted that uniformitarianism would lead to robust explanations of landforms during the twentieth century, but it seems he was as wrong about that as he was about the cycle of erosion. Why have scientists failed to explain such common, obvious features? Once confident in their explanations, geomorphologists now wander in the wilderness (Baker, and Twidale, 1991, p. 81). Could it be that their basic starting premise of uniformitarianism, or actualism, is wrong and needs to be discarded?

Modern hypotheses of landform formation incorporate rapid uplift, plate tectonics, and radiometric dating into landform evolution (Summerfield, 1991, 2000). But they still do not propose specific mechanisms to form flat, eroded land. Geomorphologists have generally quit trying to deduce the origin of landforms and have retreated into *process geomorphology*, which studies the small time and space variables operating on the earth's surface today. They hope that these detailed studies will somehow generate a general theory that will one day be able to explain the origin of landforms.

Ahnert (1998, p. 229) noted that new approaches with new methods are required to understand erosion surfaces (his peneplains): "There are still many aspects of peneplains to be explained. Perhaps some entirely new approaches with new methods are needed."

I agree that a *new* approach is needed—a catastrophic approach.

Erosion Surfaces Carved During Flood Runoff

Davis believed that a key transformation in thinking was required to understand landforms. The doctrine of the Genesis Flood, which lingered into the late 1800s in a greatly weakened state (Mortenson, 2004), had to first be overthrown.

> The emancipation of geology from the doctrine of catastrophism was a necessary step before progress could be made towards an understanding of the lands (Johnson, 1954, p. 77).

Instead, history shows that Davis's antipathy to the Flood led geomorphology into a dead end. That is because the key to geomorphology is the Genesis Flood (Oard, 2008), precisely contrary to conventional thinking over the past century.

It is looking like planation and erosion surfaces can be explained by—and only by—the retreat of Floodwaters off emerging continents. Since many planation surfaces are quite large, covering areas > 2,500 km^2, planation requires a large-scale process, best explained by the sheet-flow phase of Walker's (1994) model (Figure 38). Some additional planation undoubtedly occurred during the channelized-flow phase but at smaller scales.

Early in the retreating stage, water currents would have been changing from continental-scale flow to the megaregional scale, flowing off and away from emerging mountains, such as the Appalachians. Figure 39 presents a schematic of these processes during the planing of the Piedmont and Appalachian Plateaus Provinces. These currents would have been generally characterized by high velocities. Entrained rocks and debris would have planed the land surface, like sandpaper smoothing rough wood. Faster currents would have eroded wide areas to flat surfaces, shaving both hard and soft rocks evenly with extremely high current energy (Figure 39b,c). Where sheet currents were relatively slow, a more rolling erosional surface would have been created.

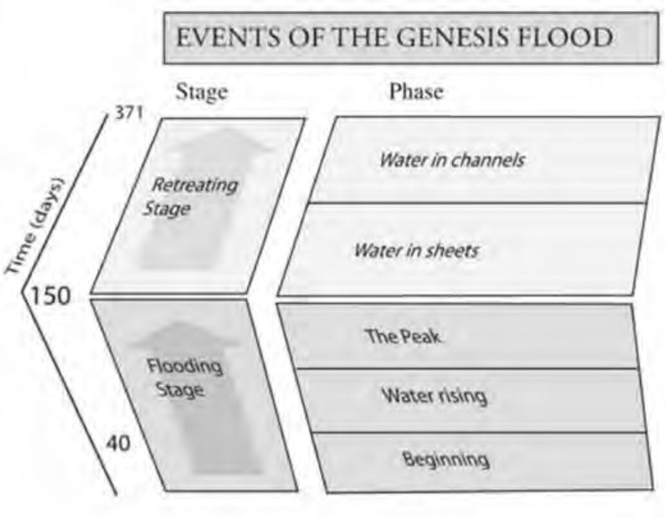


Figure 38. Walker's classification of the Flood into the 150-day flooding stage and the 221-day retreating stage with five phases.

Cobbles and boulders would have been transported in the fast turbulent flow (Figure 39c). Clasts would repeatedly crash into others, forming percussion marks. Based on the rock sizes found on top of the Cypress Hills planation surface, Klevberg and Oard (1998) estimated current velocities in excess of 30 m/sec.

Sheet-flow erosion from modern to strong currents is evident in the Piedmont and the dissected plateaus west of the Appalachian Plateau Province. But in the Valley and Ridge Province, it is likely that the currents were too weak to form an erosion or planation surface, probably because the area represented the "divide" between west-flowing and east-flowing water. The geomorphology of the Valley and Ridge Province attests to slower currents that left ridges upstanding. Ridge-perpendicular currents would have eventually cut water and wind gaps as the sheet flow was transforming into channelized flow (Oard, in press). Because of the weaker currents just west of the Blue Ridge Province, the Flood currents would have more and more been channeled down the valleys to flow parallel to the ridges. It is likely that strong channelized currents formed the Great Valley as the water was rushing toward the Atlantic Ocean in the north and the Mississippi River Valley in the south.

While the Floodwaters were planing the continental surfaces, local variations in the currents, landscape, rock hardness, and structure would result in the rapid formation of tall erosional remnants. These would include the abundant monadnocks seen on the Piedmont, especially as the Blue Ridge Escarpment was eroded toward the northwest. These monadnocks are similar to erosional remnants, like Devils Tower, in northeast Wyoming, seen in the west and explained by retreating Floodwater (Oard, 2008, 2009).

Summary

Conventional geomorphology cannot explain the landforms of the Appalachian Mountain region. However, late Flood sheet flow, operating at high velocities over large areas, can explain the landforms. During the erosion of up to 6.5 km of rock from the Appalachians, erosion surfaces were cut on both sides of the Blue Ridge Mountains. To the east is the Piedmont, a rolling erosion surface interspersed with erosional remnants

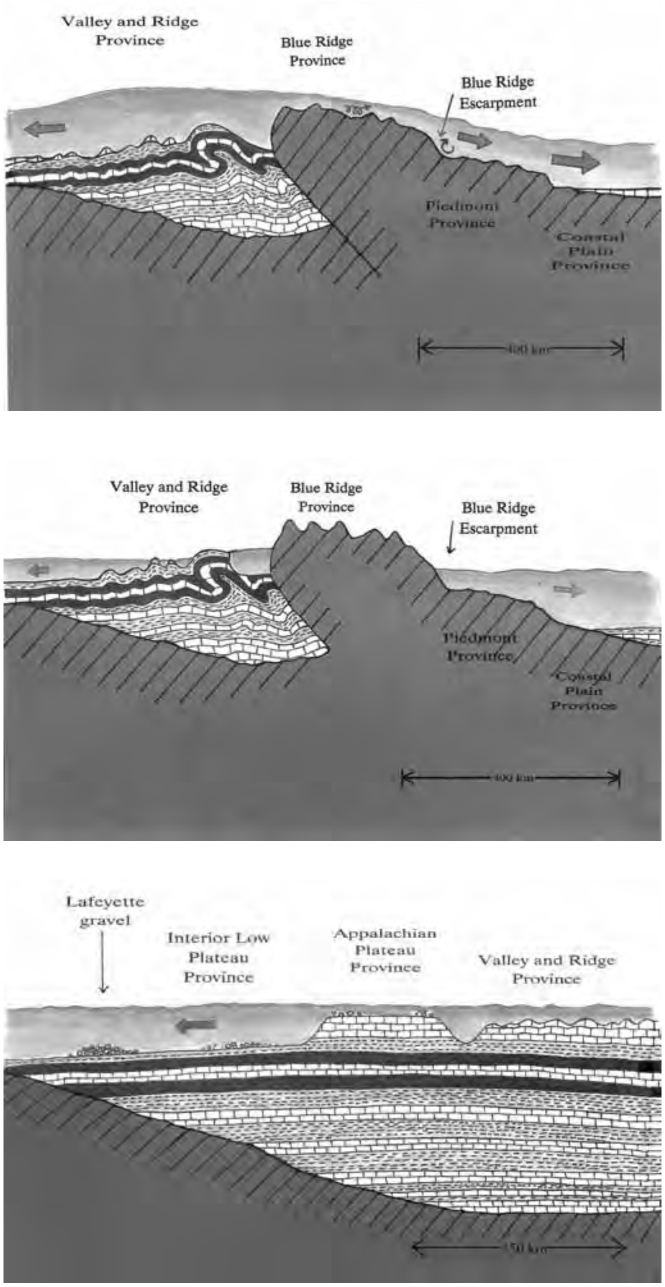


Figure 39. Summary of erosional features created during the sheet-flow phase (drawn by Melanie Richard).

(a) *(top)* Water moving off the rising Appalachians with the "divide" the Valley and Ridge Province.

(b) *(middle)* The water erodes the Blue Ridge into a mountainous terrain, but planes the Piedmont Province, leaving behind erosional remnants called monadnocks.

(c) *(bottom)* The focus shifts to the western Appalachian Basin, where the Appalachian Plateau and Interior Low Plateau Provinces planed with resistant rocks carried far to the west.

called monadnocks. Erosion planed the various igneous and metamorphic rocks down to a generally gently rolling surface. To the west, the landforms of the Valley and Ridge were formed as much by lithologic variation as by erosion, probably because current velocity was weaker than on the Piedmont. Further west, the Appalachian Plateaus Province and the Interior Low Plateaus Province are both extensive erosion surfaces caused by currents moving toward the west, away from the mountains. Resistant gravels from the Appalachian Mountains have been transported long distances east, south, and west.

William Morris Davis's "cycle of erosion" was the best uniformitarian explanation for erosion surfaces in the early 1900s. However, it suffered from a number of problems and has mostly been rejected. Several other hypotheses have been invoked, all with major problems. None of these is widely believed by actualistic scientists, and the current popular theory, the weathering hypothesis, has almost as many problems.

Large erosion surfaces would have easily formed during the sheet-flow phase of the retreating stage of the Flood. Like many similar locations worldwide, water flowing away from the rising Appalachian Mountains planed the land, creating erosion surfaces on both sides of the mountains. The speed of the erosional event, the extent of the sheet-flow currents, and the water velocity are all recorded in the presence of large erosion surfaces with erosional remnants and resistant gravels transported over great distances.

In Part III, I will describe the succeeding phase of the Flood—the channelized phase—and its geomorphological effects on the Appalachians. Its narrow currents rapidly eroded valleys, water and wind gaps, and submarine canyons offshore on the continental margin.

Acknowledgments: I thank Doug Dunbar for showing me the geomorphology of western Kentucky, especially the Lafayette Gravel, and Melanie Richard for drawing the schematic shown in Figure 39. I also thank two anonymous reviewers who significantly improved the manuscript and supplied me with the Google images and aerial photos. This work was supported by a grant from the Creation Research Society.

References

CRSQ: Creation Research Society Quarterly

JofC: Journal of Creation, Technical Journal, or Creation Ex Nihilo Technical Journal

Aadland, R.K., A.D. Smits, and P.A. Thayer. 1992. Geology and hydrostratigraphy of the A/M Area, Savannah River Site (SRS), South Carolina, USDOE Report WSRC-RP-92–440, Westinghouse Savannah River Company, Savannah River Site, Aiken, SC.

Ahnert, F. 1998. *Introduction to Geomorphology*. Arnold, London, UK.

Alden, W.C. 1932. Physiography and glacial geology of eastern Montana and adjacent areas. *U. S. Geological Survey Professional Paper 174*, Washington, DC.

Autin, W.J., S.F. Burns, B.J. Miller, R.T. Saucier, and J.I. Snead. 1991. Quaternary geology of the Lower Mississippi Valley. In Morrison, R.B. (editor), *The Geology of North America, Volume K-2, Quaternary Nonglacial Geology: Conterminous U.S.*, pp. 547–582. Geological Society of America, Boulder, CO.

Baker, V.R., and C.R. Twidale. 1991. The reenchantment of geomorphology. *Geomorphology* 4:73–100.

Birkeland, P.W. 1984. *Soils and Geomorphology*. Oxford University Press, New York, NY.

Bishop, W.W. 1966. Stratigraphical geomorphology: a review of some East African landforms. In Dury, B.H. (editor), *Essays in Geomorphology*, pp. 139–176. Heinemann, London, UK.

Bresnahan, R.P., and R.B. Van Arsdale. 2004. Denudation of the Pliocene-Pleistocene upland gravel in the upper Mississippi Embayment and its structural implications. *Geological Society of America Abstracts with Programs*, North-Central Section, 38th annual meeting 36(3):47.

Briggs, R.P. 1999. Appalachian Plateaus Province and the eastern lake section of the Central Lowland Province. In Shultz, C.H. (editor), *The Geology of Pennsylvania*, pp. 363–377. Pennsylvania Geological Survey, Harrisburg, PA, and Pittsburgh Geological Society, Pittsburgh, PA.

Chorley, R.J., R.P. Beckinsale, and A.J. Dunn. 1973. *The History of the Study of Landforms or the Development of Geomorphology—Volume Two: The Life and Work of William Morris Davis*. Methuen & Co. LTD, London. UK.

Crickmay, C.H. 1933. The later stages of the cycle of erosion: some weaknesses in the theory of the cycle of erosion. *Geological Magazine* 70:337–347.

Crickmay, C.H. 1972. Discovering a meaning in scenery. *Geological Magazine* 109:171–177.

Crickmay, C.H. 1974. *The Work of the River: A Critical Study of the Central Aspects of Geomorphology*. American Elsevier Publishing Co., New York, NY.

Dennison, J.M. 1976. Gravity tectonic removal of cover of Blue Ridge anticlinorium to form Valley and Ridge province. *GSA Bulletin* 87:1,470–1,476.

Ehlers, J. 1996. *Quaternary and Glacial Geology*. John Wiley & Sons, New York, NY.

Faniran, I.A. 1974. Nearest-neighbour analysis of inter-inselberg distance: a case study of the inselbergs of South-Western Nigeria. *Zeitschrift für Geomorpholgie N. F.* 20:150–167.

Farrar, S.S., 1985. Tectonic evolution of the easternmost Piedmont, North Carolina. *GSA Bulletin* 96:362–380.

Fenneman, N.M., 1938. *Physiography of Eastern United States*. McGraw-Hill Book Company, Inc, New York, NY.

Flemal, R.C. 1971. The attack on the Davisian system of geomorphology: a synopsis. *Journal of Geological Education* 19:3–13.

Froede, C.R., Jr. 1995. Stone Mountain, Georgia: a creation geologist's perspective. *CRSQ* 31:214–224.

Froede, C.R., Jr. 2006. Neogene sand-to-pebble size siliciclastic sediments on the Florida peninsula: sedimentary evidence in support of the Genesis Flood. *CRSQ* 42:229–240.

Froede, C.R., Jr. 2009. From the Appalachians to the Keys: an update on the Florida gravels. *Creation Matters* 14(3):1–3.

Hack, J.T. 1989. Geomorphology of the Appalachian Highlands. In Hatcher, R.D., Jr., W.A. Thomas, and G.W. Viele (editors), *The Geology of North America, Volume F-2, The Appalachian-Ouachita Orogen in the United States*, pp. 459–470. Geological Society of America, Boulder, CO.

Hall, K.J. 1988. Weathering. In Moon B.P., and G.F. Dardis (editors), *The Geomorphology of Southern Africa*, pp. 12–29. Johannesburg, South Africa.

Hart, M.G. 1986. *Geomorphology Pure and Applied*. George Allen & Unwin, London, UK.

Hatcher, R.D., Jr. 1972. Development model for the Southern Appalachians. *GSA Bulletin* 83:2,735–2,760.

Johnson, D.W. (editor). 1954. *Geographical Essays by William Morris Davis*. Dover Publications, Mineola, NY.

King, L. 1966. The origin of bornhardts. *Zeitschrift für Geomorpholgie N. F.* 10(1):97–98.

King, L. 1975. Bornhardt landforms and what they teach. *Zeitschrift für Geomorpholgie N. F.* 19:299–318.

Klevberg, P., and M.J. Oard. 1998. Paleohydrology of the Cypress Hills Formation and Flaxville gravel. In Walsh, R.E. (editor), *Proceedings of the Fourth International Conference on Creationism*, technical symposium sessions, pp. 361–378. Creation Science Fellowship, Pittsburgh, PA.

Mortenson, T. 2004. *The Great Turning Point:"The Church's Catastrophic Mistake in Geology—Before Darwin."* Master Books, Green Forest, AR.

Neuendorf, K.K.E., J.P. Mehl Jr., and J.A. Jackson. 2005. *Glossary of Geology*, fifth edition. American Geological Institute, Alexandria, VA.

Oard, M. J. 2004. *Frozen in Time: The Woolly Mammoth, the Ice Age, and the Bible*. Master Books, Green Forest, AR.

Oard, M.J. 2008. *Flood by Design: Receding Water Shapes the Earth's Surface*. Master Books, Green Forest, AR.

Oard, M.J. 2009. Devils Tower can be explained by floodwater runoff. *JofC* 23(2):124–127.

Oard, M.J. 2011. Origin of Appalachian geomorphology part I: erosion by retreating floodwater and the formation of the continental margin. *CRSQ* 48:33–48.

Oard, M.J. Origin of Appalachian geomorphology part III: channelized erosion late in the Flood. *CRSQ* (in press).

Oard, M.J., J. Hergenrather, and P. Klevberg. 2005. Flood transported quartzites—east of the Rocky Mountains. *JofC* 19(3):76–90.

Oard, M.J., and P. Klevberg. 1998. A diluvial interpretation of the Cypress Hills Formation, Flaxville gravels, and related deposits. In Walsh, R.E. (editor), *Proceedings of the Fourth International*

Conference on Creationism, technical symposium sessions, pp. 421–436. Creation Science Fellowship, Pittsburgh, PA.

Ollier, C., 1991. *Ancient Landforms*. Belhaven Press, New York, NY.

Owens, J.P. 1999. Cretaceous and Tertiary. In Shultz, C.H. (editor), *The Geology of Pennsylvania*, pp. 219–223. Pennsylvania Geological Survey, Harrisburg, PA, and Pittsburgh Geological Society, Pittsburgh, PA.

Owens, J.P., and J.P. Minard, 1979. Upper Cenozoic sediments of the Lower Delaware Valley and the Northern Delmarva Peninsula, New Jersey, Pennsylvania, Delaware, and Maryland. *U. S. Geological Survey Professional Paper 1067-D*, Washington, DC.

Pazzaglia, F.J. 1993. Stratigraphy, petrography, and correlation of late Cenozoic middle Atlantic Coastal Plain deposits: implications for late-stage passive-margin geologic evolution. *Geological Society of America Bulletin* 105:1,617–1,634.

Phillips, J.D. 2002. Erosion, isostatic response, and the missing peneplains. *Geomorphology* 45:225–241.

Potter, P.E. 1955a. The petrology and origin of the Lafayette gravel Part I. Mineralogy and petrology. *Journal of Geology* 63:1–38.

Potter, P.E. 1955b. The petrology and origin of the Lafayette gravel Part II. Geomorphic history. *Journal of Geology* 63:115–132.

Pugh, J.C. 1966. The landforms of low latitudes. In Dury, B.H. (editor), *Essays in Geomorphology*, pp. 121–138. Heinemann, London, UK.

Römer, W. 2005. The distribution of inselbergs and their relationship to geomorphological, structural and lithological controls in southern Zimbabwe. *Geomorphology* 72:156–176.

Schlee, J. 1957. Upland gravels of southern Maryland. *Geological Society of America Bulletin* 68:1,371–1,410.

Small, R.J. 1978. *The Study of Landforms: A Textbook of Geomorphology*, second edition. Cambridge University Press, London, UK.

Stose, G.W. 1928. High gravels of Susquehanna River above Columbia, Pennsylvania. *Geological Society of America Bulletin* 39:1,073–1,086.

Summerfield, M.A. 1991. *Global Geomorphology*. Longman Scientific & Technical, New York, NY.

Summerfield, M.A. 2000. Geomorphology and global tectonics: Introduction. In Summerfield, M.A. (editor), *Geomorphology and Global Tectonics*, pp. 3–12. John Wiley & Sons, New York, NY.

Taylor, R.G., and K.W.F. Howard. 1998. Post-Palaeozoic evolution of weathered landsurfaces in Uganda by tectonically controlled deep weathering and stripping. *Geomorphology* 25:173–192.

Thomas, M.F. 1978. The study of inselbergs. *Zeitschrift für Geomorpholgie N. F.* 31:1–41.

Thomas, M.F. 1994. *Geomorphology in the Tropics: A Study of Weathering and Denudation in Low Latitudes*. John Wiley & Sons, New York, NY.

Thomas, M.F., and M.A. Summerfield. 1987. Long-term landform development: key themes and research problems. In Gardiner V. (editor), *International Geomorphology*, Part II, pp. 936–956. John Wiley & Sons, New York, NY.

Thornbury, W.D. 1965. *Regional Geomorphology of the United States*. John Wiley & Sons, New York, NY.

Twidale, C.R., 1981. Granitic inselbergs: domed, block-strewn and castellated. *Geographic Journal* 147 (1):54–71.

Twidale, C.R. 1982. The evolution of bornhardts. *American Scientist* 70:268–276.

Twidale, C.R. 2004. River patterns and their meaning. *Earth-Science Reviews* 67:159–218.

Twidale, C.R., and J.A. Bourne. 1998. Origin and age of bornhardts, southwest Western Australia. *Australian Journal of Earth Sciences* 45:903–914.

Walker, T. 1994. A Biblical geological model. In Walsh, R.E. (editor), *Proceedings of the Third International Conference on Creationism*, technical symposium sessions, pp. 581–592. Creation Science Fellowship, Pittsburgh, PA.

Willis, B., 1936. *East African Plateaus and Rift Valleys*. Carnegie Institution of Washington, Washington D.C.

Hurricane Katrina Splay Deposits: Hydrodynamic Constraints on Hyperconcentrated Sedimentation and Implications for the Rock Record

W.R. Barnhart*

Abstract

A breach of the London Avenue Canal levee in New Orleans' Lower Ninth Ward during Hurricane Katrina created a unique opportunity to compare flow conditions with the resulting bedforms. Those deposits are examined and correlated to probable hydrodynamic conditions during deposition, including the fluctuating causes for repetitive bedforms and changing conditions within the continuous unidirectional current through the breach. Flow depth was determined mathematically from clast size and is examined as a limit on bedform thickness. Characteristics of the splay deposits point to deposition under hyperconcentrated conditions in a high-velocity current, leading to a remarkably high depositional rate. This study suggests a mechanism for the simultaneous deposition of multiple laminae as a single set under hyperconcentrated conditions. Clay and clay drapes in the deposit indicate fluctuations in flow, not a cycle of active/passive sedimentation.

Introduction

The interpretation of sedimentary rocks and their bedforms has been at the heart of geology since its inception, because the features of rocks provided an open door to speculation about their origin. Early attempts were largely qualitative, centering around speculative assumptions of the presumed paleoenvironment. Each environmental setting became identified as a facies, and their description was driven by assumptions such as deep time and strict uniformitarian rates of progress. The advent of quantitative sedimentology, with its basis in physics rather than environmental constraints, has provided an alternate means of understanding features on many scales, though the stratigraphic placement in the geologic column and the associated paleoenvironmental paradigm has continued to constrain most contemporary interpretations.

Today, with decades of investigation—largely driven by fluid mechanics—sedimentologists are applying mathematical precision to many aspects of sedimentary rocks, using physical properties of the grains and their bedding to derive flow velocity, depth, and other diagnostic features. Sedimentary bedforms, because they persist in the rock record, have provided a means to work from bedforms and grain characteristics to mathematically derive likely environmental factors such as velocity, flow

---

* W.R. Barnhart, c/o Creation Research Society, Chino Valley, AZ

Accepted for publication January 22, 2011

depth, concentration, and the rate of deposition under the original conditions.

Quantitative sedimentology is hard science; it provides an invaluable forensic tool to help us understand the past. The detailed study of modern examples, in nature and in the laboratory, provides constraints on interpretation. McLane (1995, p. 84, parentheses in original) noted that, "Sedimentary structures (in conjunction with body fossils, if they exist) constitute the major evidence in our diagnosis of depositional environments." Bedforms, especially at the millimeter to centimeter (mm to cm) scale, offer an opportunity to ascertain the processes and energy relationships that create them. A recent example of an unusual event was the splay deposits created by levee breaches in New Orleans during and after Hurricane Katrina. These demonstrated a cause-and-effect link between well-constrained fluid/sediment interactions and their bedforms. A close study of these deposits is valuable because they provide application to splay deposits, sedimentary processes in the high-energy environment of a hurricane, and complex hydrodynamic processes applicable to the rock record.

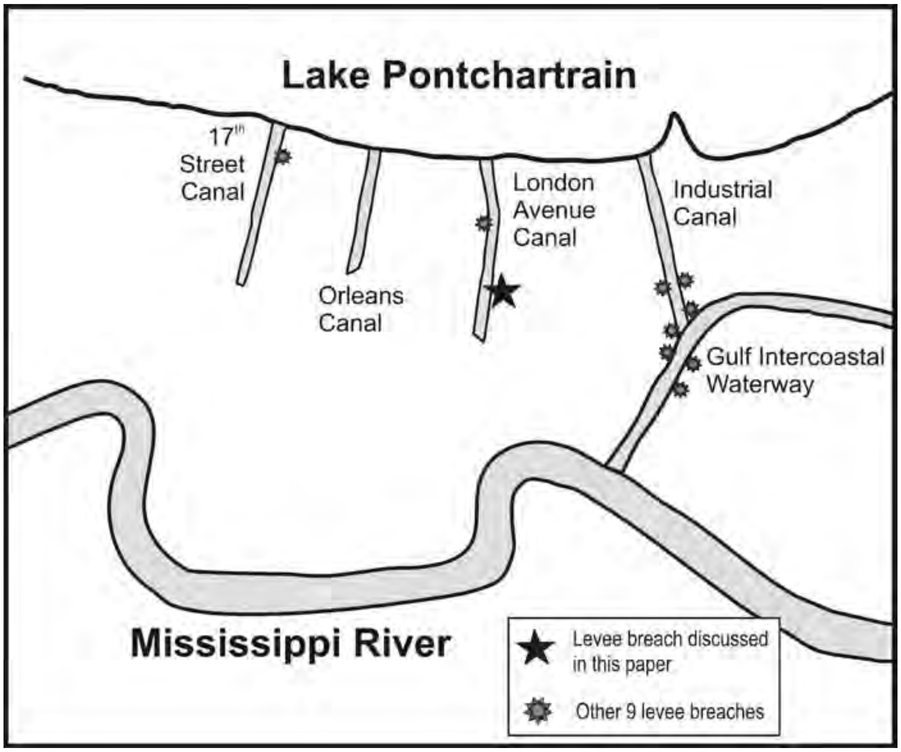


Figure 1. Map of New Orleans showing locations of levee breaches and the breach studied in this paper.

New Orleans was settled during the 1700s on a natural levee of the Mississippi River north of Lake Pontchartrain. As the terminus for Mississippi River trade, by the early 1800s, the city had expanded into the low-lying swampland between the river and lake. Some of this converted swampland lay up to -1.9 m (-6.2 ft) mean sea level (msl) and 2.5 m (8.2 ft) below lake level, normally 0.6 m (2 ft) above sea level (Nelson and Leclair, 2006). Over the years, a series of levees were constructed along the river and lake, and canals provided shipping lanes between the lake and the river. Other drainage canals extend from largely residential areas of the city into the lake (Figure 1). All modern levees exceed the lake water level and are capped by a concrete flood wall rising an additional 1.4 m (4.6 ft) above lake level, or 2 m (6.6 ft) above msl. The Lower Ninth Ward and the lakefront area drained by the London Avenue Canal are typical of areas built on low-lying swampland.

Geologically, much of the city rests on channel fill and delta deposits of the Mississippi River referred to as Gentry Ridge (Nelson and Leclair, 2006). A prominent body of mature white sand, the Pine Island Beach Sands (PIBS), underlies both Gentry Ridge deposits and lower-lying residual swamp deposits (RSD), on which residential areas from the lake to the Lower Ninth Ward were built (Eustis Engineering, 1986). The PIBS is believed by Nelson and Leclair (2006) to be an old sand spit created by east-west longshore Gulf of Mexico currents (Figures 2 and 3). These sands lie between Lake Pontchartrain and the present-day gulf, deposited in similar fashion to Dauphin Island off the coast of Alabama (Froede 1995).

Following Katrina, researchers investigated the causes of the flooding. Two of the most prominent studies were completed by Louisiana State University and the University of California, Berkeley. During the cleanup effort, a team from Tulane University mapped and photographed the sediment surfaces and some of the cross sections in the area of the southeast breach of the London Avenue Canal (Nelson and Leclair, 2006, their figure 4). Research was ended by the rapid cleanup of flood sediments and the absence of direct eyewitness accounts of the relevant flooding, but photos and reports provide a surprisingly complete record for evaluation of the sedimentation during levee breaches (Nelson and Leclair, 2006). This paper will focus on the southeast London Avenue Canal levee breach, photographed and described in the Tulane report (Nelson and Leclair, 2006).

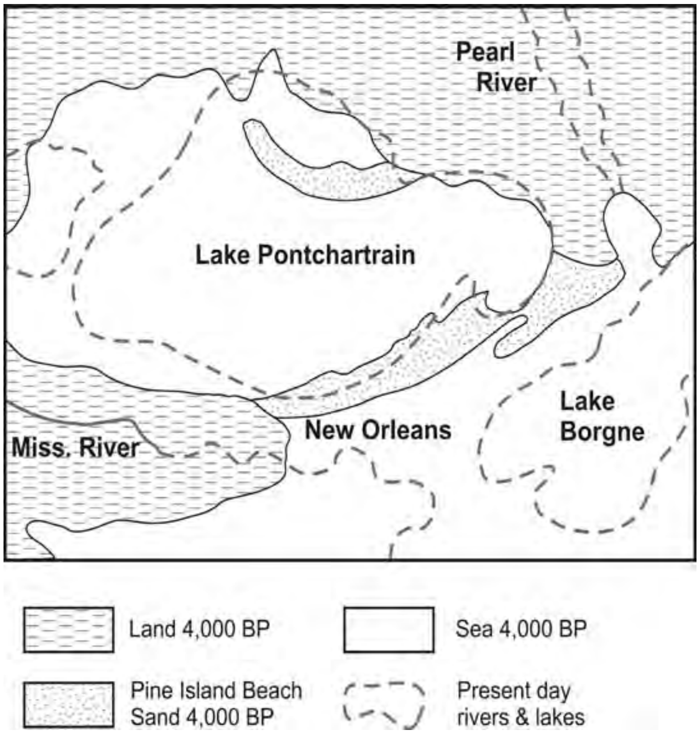
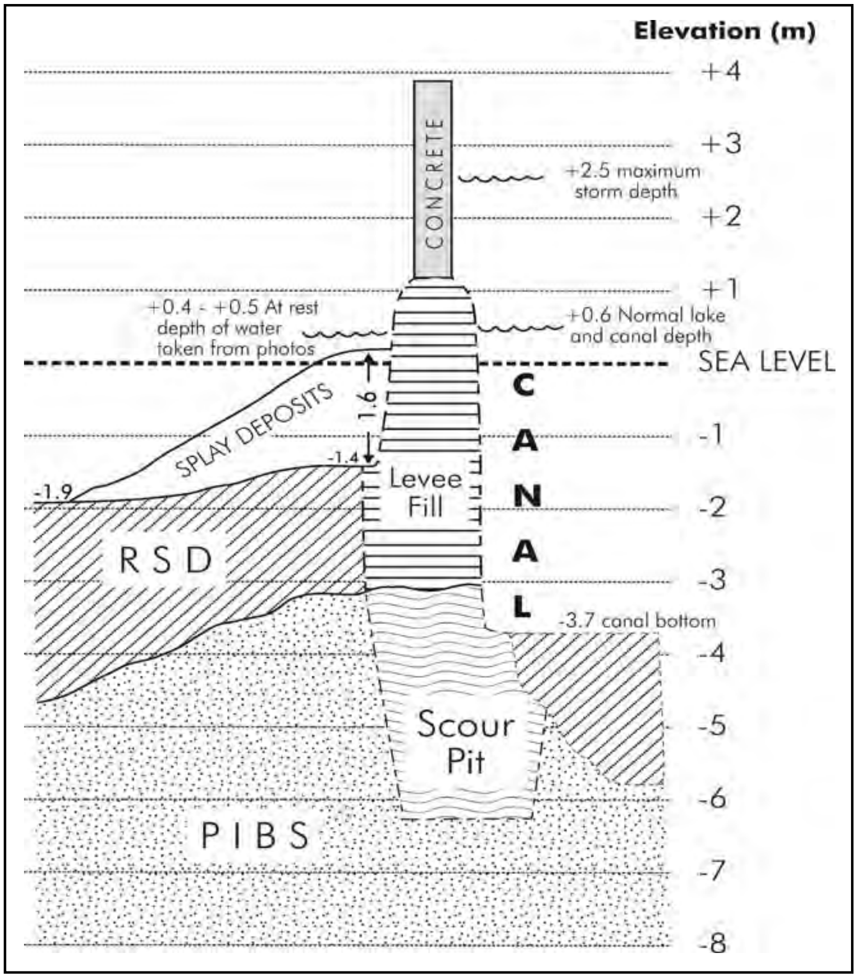


Figure 2 *(left)*. **Probable configuration of Pine Island Beach Sand in relationship to land and sea in 4,000 BP. Two sand spits developed from east-west longshore currents. The northern one is now under Lake Pontchartrain, and the second underlies much of New Orleans and St. Bernard Parish. After Nelson and Leclair (2006, figure 2).**

Figure 3 *(below)*. **East to west cross section of land and canal elevations adjacent to London Avenue Canal levee showing comparative heights. Splay deposit height of 1.6 m used for comparison of wave and flow depth at measured cross section. All elevations relative to sea level.**



Correlation of maps, cross sections of sediments, and published descriptions of the conditions allow a detailed understanding of the hydrodynamic processes and the bedforms they produced. The levee breach can be viewed as a natural-scale flume experiment, at a scale unavailable in the laboratory. The Katrina splay deposits were produced by the interaction between sediment source, water surface gradients, winds, waves, currents, current pathways, and local obstructions. This study is significant because it provides sedimentological constraints on bedforms observed in the rock record. Specifically, it demonstrates that several sequences of bedforms previously interpreted as indicating long periods of time, can be formed in a matter of minutes. Thus, understanding these deposits and their physical causes will better constrain interpretation of much larger, but similar, features found in strata (Reed and Froede, 2009).

Hurricane Katrina and the New Orleans Canal Breaches

Hurricane Katrina made landfall over Florida, regained strength in the Gulf of Mexico, and curved northeast to strike the Louisiana and Mississippi coasts. It crossed New Orleans and the adjacent St. Bernard Parish at about 6:10 am, CDT on 29 August 2005, as a Category 3/4 hurricane, with sustained winds of over 205 kph (125 mph) (Knabb and Rhone, 2005). At 8:14 AM CDT, the National Weather Service issued a flash flood warning for New Orleans and St. Bernard parishes, citing a levee breach on the Industrial Canal (Place of Dead Roads, 2005). This breach appears to have been caused by overtopping of the levee wall by a storm wave up to 7 m (23 ft) high, moving up the Gulf Intracoastal Waterway (Figure 1). The wave apparently struck the levee wall broadside (Seed, 2005). The levee failed, and its breach was quickly enlarged. Within 46 minutes, by approximately 9:00 AM CDT, the Lower Ninth Ward was reported to be inundated by 1.8–2.4 m (6–8 ft) of water (McQuaid, 2005a).

Initially, residents of lakefront areas of Lake Pontchartrain and those of other parts of the city, away from the larger shipping canals (Figure 1), thought they had escaped. None of the levees bordering the 17th Street Canal, the London Avenue Canal, or Lake Pontchartrain were ever reported as being overtopped by the storm surge. This may be because the lake, not being open to the gulf, did not propagate waves of sufficient size. However, other factors caused several additional levee failures throughout the city. Homeowners near the 17th Street Canal had previously reported water seeping into their yards (Marshall, 2005). Berkeley researchers attributed the catastrophic failure of the 17th Street Canal and the London Avenue Canal levees to erosive undermining in the RSD and PIBS (McQuaid, 2005b; Nelson and Leclair, 2006).

Water gushed through these breaches until the elevation head of the flooded areas equalized with the lake. That head pressure created flow through the breaches sufficiently powerful to dislodge and move a house. As the pressure difference decreased, flow velocity diminished. The lateral extent of the highest velocity was quite restricted; strong at the breaches—as indicated by the erosional absence of sediments—and weaker moving away. Resulting areas of erosion and deposition were observed after the floodwaters were pumped back into the canals. Nelson and Leclair (2006, their figure 5b) provided a pre-cleanup photo of the passage between the second and third houses north of the breach and the bare ground between them covered with grass. Although sand in the street was still more than waist deep, no significant sediment was ever able to settle in this area. As the current began to disperse and wane, sediment was deposited in mounds, often dictated by local obstructions, as the current shifted from supercritical to subcritical flow.

Subsequent action by counter currents, wave action, or pumping was insufficient to substantially alter the initial depositional/erosional patterns. This suggests that (1) maximum deposition and the resulting bedforms were produced very rapidly—within a maximum of the 46 minutes required to equalize the elevation head in the Lower Ninth Ward—and (2) deposition of the sediments and creation of bedforms was continuous, as was the flow. Deposition of bedforms occurred only while the current was at its highest velocity, flowing outward from the canals. Bedforms were not significantly altered during the subsequent three-week inundation or later pumping. Thus, the observed form and sequence of bedforms reflects the hydrodynamics of the breach—a high-velocity, unidirectional current. Understanding the current's direction, speed, consistency, and duration provides significant hard data for interpreting its sedimentary products.

The Physical Materials

Deposits are a direct function of available sedimentary material, so this section will examine those sources at the London Avenue Canal breach and the relationship between the source and the depositional sites.

The levee breach eventually widened to 61 m (200 ft), but the initial flow through the narrower outlet can be estimated from a house that was carried some distance. The current struck the southwest corner of the house, rotating it as it moved off its foundations. Another indication of the flow's power was seen by divers during levee repairs. They estimated that a scour pit had been excavated; Nelson and Leclair report the hole as being 6.1 m (20 ft) below sea level, or about 2.4 m (7.9 ft) below the original canal bottom. If the scour depth were actually below the canal floor, then it would account for some of the splay sediment and the high proportion of PIBS (Figure 4). That scour was less than that in other flooding (e.g., Vink, 1926), perhaps because of the shorter duration of the eroding current and the smaller flood basin.

Using the calculation of 6.1 m below sea level, Nelson and Leclair (2006) estimated the volume of the scour to be about 7,800 m^3, which accounts for only 29% of the 26,380 m^3 of sediment deposited in the immediate area. The rest of the sediment must have come from artificial levee fill (ALF), RSD, eroded topsoil, and other areas of the canal bottom. Sediment deposited on the neighborhood side of the breach included several different compositions (Figure 3) and formed several distinct layers (Figure 5).

At the breach, the PIBS deposits lay no more than 2 m (6.6 ft) below the original canal bottom (Nelson and Leclair, 2006), probably overlain by RSD (Figure 4). Nelson and Leclair described it as "a 1.5 m to 3 m thick layer of organic-rich clays that contains peat and wood fragments" (2006, p. 2). Above it, a layer of well-consolidated fine clay covered the canal bottom. This layer was peeled up in sheets and rolled into sand-to-pebble size clay balls that were then deposited as clasts in the splay sediments. The ALF constituted the other significant source of sediment from the canal (Figures 3 and 4) and was the major component of the lowest, largely–unsorted clastic Layer A (Figure 5), along with a significant volume of clay balls (Figure 6). Nelson and Leclair (2006, p. 2) reported: "The artificial levee fill consists mostly of clays with pockets of sand, silt, and occasional logs and shells."

Sedimentary deposits in the study area covered about 54,670 m^2 (Nelson and Leclair, 2006) in an irregular pattern determined largely by local obstructions. Total thickness varied from 1.8 m (5.9 ft) near the breach to < 0.3 m (1 ft) about 400 m (1,312 ft) away. This resulted in a reported slope on the sediment surface of about 0.004.

Sediment was entrained in the current in several distinct ways. One was by direct flow, but several indirect factors proved important. One was liquefaction of the PIBS. Water in the canal is normally at the same level as Lake Pontchartrain, 0.6 m (2 ft) above sea level. The storm surge at the canal was 1.9 m (6.2 ft), and so the maximum wave height in the canal would have been at 2.5 m (8.2 ft) above sea level (Figure 3) (Nelson and Leclair, 2006). The canal bottom, at -3.7 m (-12 ft) msl, would have been well above the storm wave base, forcing each storm surge to pump water into the PIBS (-5.7 m msl) like a huge piston. Hydrostatic pressure would have caused liquefaction, decreasing PIBS cohesion and shear strength. This weakness at the base of the levee's core of sheet piling, combined with the weight of the heavy concrete parapets atop the levee, forced the catastrophic structural failure.

At that point, a powerful current, which flowed into the neighborhood and began widening the breach, scoured the immediate area near the breach, and deposited sediment as the flow dispersed or was slowed by obstacles. During that time, more energy was added to the system by storm waves surging up the canal. Each one would further erode the scour pit, adding additional, corresponding pulses of sediment to the outflow. Flow was powered by a fall height of up to 4 m (13 ft), with a functional head pressure equal to the total mass of the top 2 m (6.6 ft) of water in Lake Pontchartrain. That was why the initial flow was sufficient to dislodge and move a house. Torn from its concrete foundation, it floated 36 m (118 ft) down current until it wedged against a large tree, rotating 137° clockwise due to the slightly off-center pressure (Nelson and Leclair, 2006). High current strength was also illustrated by the lack of sedimentation between the breach and the final resting site of the house, caused by high current velocities.

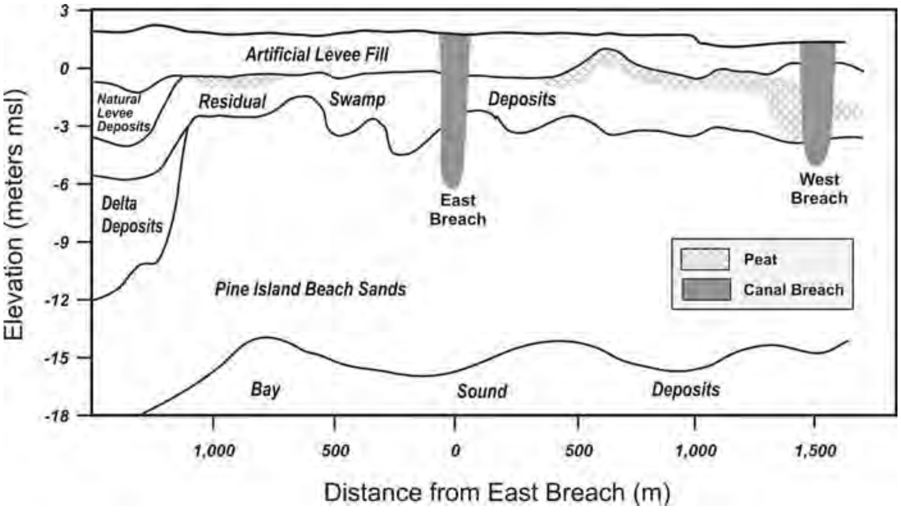
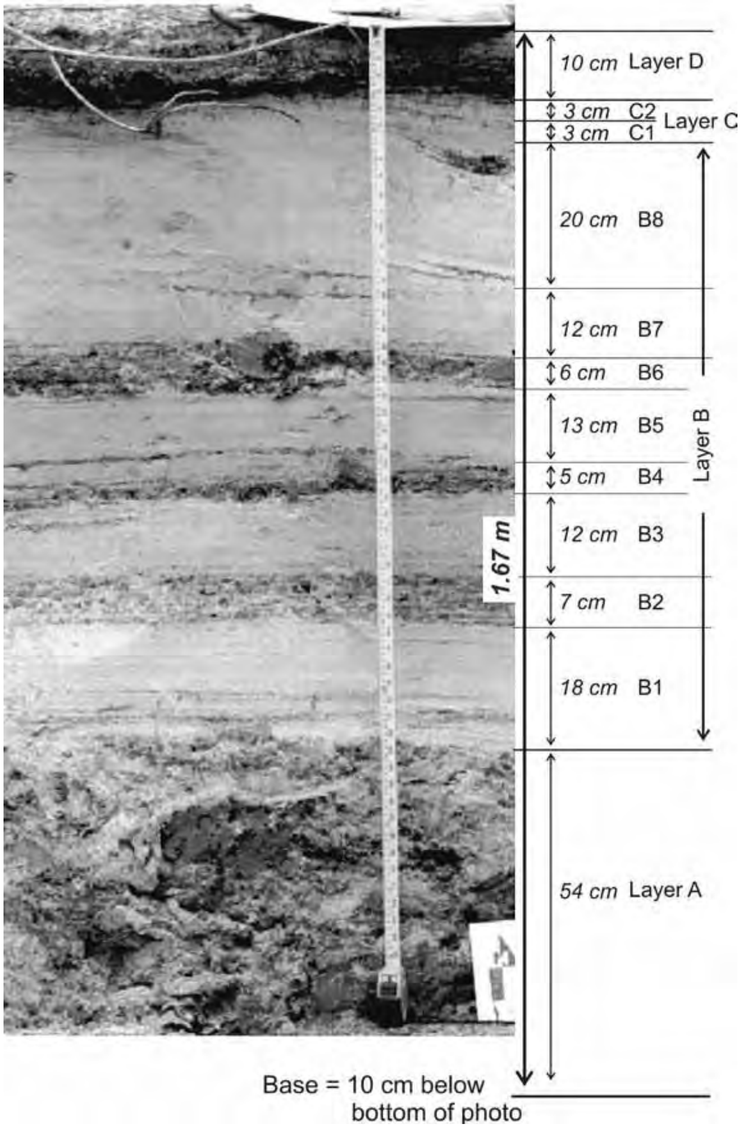


Figure 4. Cross section of major sedimentary deposits under the London Avenue Canal neighborhood from south to north. This study is of the east breach. After Nelson and Leclair (2006, figure 3).

Splay Sedimentation at the Breach

Flow through the breach resulted in the development of a splay deposit, with characteristics that indicate the mechanics of the water flow. Figure 5 and its accompanying diagrammatic version, Figure 6, show one of the thickest and most complete cross sections through the splay. Nelson and Leclair (2006, p. 3) concluded, "It is clear that the sand originated from the buried Pine Island beach deposits in the subsurface." However, there are both white and pink sand grains present in the splay. Because the PIBS is white (Figure 6), the pink sand, probably colored by oxidized iron or residual organic matter, probably comes from RSD, or possibly the PIBS was colored by a mixture of RSD. Layer A, the basal deposit (Figures 5 and 6), is assumed to be ALF. Ubiquitous clay balls are probably from the canal bottom clay; thus all four sediments in the area of the breach contributed to the splay sediments. Since the scour pit provided less than 30% of the total sediment, it is likely that similar material was carried up the canal (Nelson and Leclair, 2006). It is also possible that it was derived from the scour pit on the west side of the London Avenue Canal, just to the north. Thus, sediment (except for Layer D, discussed later) originated locally. Nelson and Leclair (2006, p. 3) determined, "The sand fraction in all parts of the splay deposits consisted of fine sand (0.125–0.25mm)."



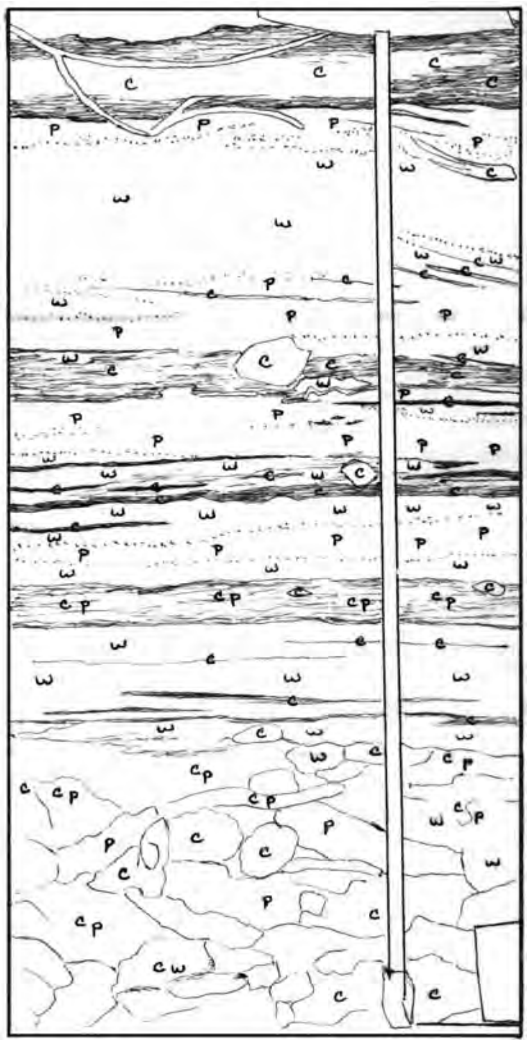


Figure 5 ***(left)*****. Vertical cross section through nearly the complete deposit at Point X, Figure 7, on west side of Warrington Drive. Bottom of Layer A is in standing water 10 cm below measured section shown, for a total of 1.63 m. Measurement of layers approximated from scale in photo. From Nelson and Leclair (2006, figure 6 with dimensions added).**

Figure 6 ***(right)*****. Redrawing of Figure 5 showing the areas where primary composition is pink sand (P), white sand (W), and clay (C) in the cross section. From Nelson and Leclair (2006, their figure 6).**

Assuming most of the sediment came from the immediate area, how was so much material entrained in such a limited distance? Would the rapid current alone provide the necessary force to suspend and transport this quantity of sediment? A particle at rest on the bottom of the canal would have experienced gravitational and frictional forces—both adhesive and cohesive—that would tend to keep the particle on the bottom. To move up into the current, it would have to experience equal or greater hydrodynamic lift forces. These forces can be produced by (1) irregularities in the flow and (2) irregularities in the particle. The part of a current that interacts with substrate particles is called the boundary layer. In shallow water it may extend to the surface. Below this layer, water moves between particles in the substrate in what is called the absorbed layer, where cohesive forces prevail. Between the boundary layer and the absorbed layer is the viscous sublayer, where viscous forces prevail (Nichols, 1999, p. 43).

Under normal flow conditions, turbulence is caused by irregularities in the sediment surface within the viscous sublayer. Rarely, turbulence may be caused by forces acting on the water/air interface and may extend as far as the absorbed layer. Turbulence produces upward flow, carrying particles up into the current. Particle lift also occurs by Bernoulli forces (McLane, 1995). However, Southard (1971) established that in laminar flow with low turbulence, Bernoulli forces alone will not cause an appreciable quantity of fine sand to enter the suspended load.

PIBS and RSD sediments at the canal bottom were protected by a layer of well-consolidated clay—the source of clay balls and drapes in the deposits. Hjulström's diagram (reproduced in Nichols, 1999) indicates that the erosion of consolidated clay requires velocities up to 3 m/s in water approximately 1 m deep. Calculations will show that the mean water velocity at the breach did not attain this rate under normal flow. McLane (1995, p. 58, brackets added) noted: "Grains smaller than this [1.0 mm] do not project very far into the flow; their movement is due mainly to viscosity of the flow and is largely independent of turbulence." So if neither Bernoulli forces nor turbulence were sufficient, what added enough energy to create hydrodynamic lift at the London Avenue Canal? I suggest that storm surge waves are the answer.

These waves generally have a long wavelength but travel rapidly. McLane (1995) suggested storm surge waves with a 20-second interval would possess wavelengths of 600 m (1,968 ft), moving at 30 m/s. Wave base for such a wave would be one half the wave length, or 300 m (984 ft). This is far deeper than the 6 m (20 ft) shown in Figure 3 at the depth of the canal. Thus, these waves would transfer significant energy directly down onto the canal bottom. The canal depth would cause the storm waves to react as shallow water waves (McLane, 1995), where water particles travel in ellipses, not circles. The vertical component of that motion would act as a hydraulic pump, pushing water into the substrate while the extended horizontal motion (from the wavelength) would peel up the protective layer of consolidated clay. Thixotropic conditions would overcome the cohesion of the underlying sand, allowing it to be easily entrained in the current. This is shown by the equation for the length (l_1) of the horizontal semi-major axis:

$$l_1 = a/kD \qquad (1)$$

Where a = ½ the wave amplitude, $k = 2\varpi/L$ where L = wave length as determined by storm wave interval, and D = depth to bottom, the distance over which energy was dissipated.

The height (l_2) of the vertical semi-minor axis is:

$$l_2 = a\,(y+D)\,/\,D \qquad (2)$$

Where $y = 0$ at the water's surface and $y = -D$ at the bottom, where "the ellipse degenerates into a horizontal line" (McLane, 1995, p. 70).

Since the precise timing of the canal storm waves was not measured, I will assume a 20 second surge, along with the reported wave height of 1.9 m (6.2 ft). When a given wave ellipse had a semi-minor axis of 0 against the bottom, they would have a semi-major axis of about 33.3 m (110 ft) or a horizontal length of 67 m (220 ft). With energy concentrated in the forward horizontal motion, the entire power of the 1.9 m surge crest would scour the clay surface, peeling back large flakes and sheets. The exposed thixotropic sand would then lift easily into the current.

There was still some vertical vector of wave motion. Given the bottom roughness, caused by the original breach and scour (constantly being enlarged), considerable turbulence would have resulted. Equation (2) shows that 1 m (3.3 ft) above the bottom, the ellipse would have had about 0.67 m (2.2 ft) of vertical motion. Yet head pressure from Lake Pontchartrain was sufficient to force unidirectional flow, limiting the amount and effective direction of turbulence so that significant stirring of the sediments could not occur. As a result, sedimentary units are distinct and deposited in the order they were entrained.

If Layer A (Figure 5) formed from the first blowout of ALF, then sublayer B1 likely represents additional mining of PIBS with an energy pulse that eroded canal bottom clay, producing the line of clay in the lower part of B1. Three couplets, sublayers B2 through B7, reflect three additional, distinct energy pulses in the current—probably surge waves and their attendant wave trains. If so, they would have first stripped the clay off the bottom, unmasking the PIBS and RSD sands, which were then quickly entrained. The B2/B3 couplet may have been interrupted by the B4/B5 surge, indicating backwards erosion from the original scour up the canal and acquiring the sediment for the next sequence—B6/B7.

Assuming the original canal bottom consisted of (1) canal bottom clay, (2) RSD, and (3) PIBS, in that vertical order, and based on the depth of the original scour, once the white PIBS from the scour was deposited in B1, erosion back up the canal channel would have removed the pink RSD, the primary sand in B3, B5, and B7 (Figure 6). This suggests that storm surge ellipses were *widening* the original scour rather than deepening it. Even in the top half of Layer A, the pink sand indicates RSD. This storm surge theory is supported by the regularity of these couplets, particularly the similar thickness of the sublayers.

If the underlying current was constant and regular (based on the large pressure head), the couplets suggest overlaying energy pulses. But if this accounts for B1 through B7, what was the origin of Layer A's distinct structure?

A possible answer is found in the nature of the breach. The sheet metal pilings that were the functional core of the levee failed catastrophically, resulting in a wall of mud and water surging through the breach. This most likely occurred in conjunction with a storm surge, 2.5 m (8.2 ft) above msl. With the protected land at -1.4 m (-4.6 ft) msl, that explosive wall of water would have been up to 3.9 m (12.8 ft) high, though it probably dropped to 2.5–3.0 m (8.2–9.8 ft) almost immediately. Even so, this is nearly the height of the local houses. Layer A was the result of this initial wave. The lack of sediments around the foundation of the displaced house and beyond (Figure 7) suggests that the current there was supercritical and moved through the area as a turbidity current, driven by the slope of the falling water and the head pressure. "Beyond the mouth of the channel [avulsion] the flow spreads and weakens, and the turbidity current eventually collapses and deposits its suspended load" (McLane, 1995, p. 79, brackets added). Layer A, composed of a wide variety of materials with clasts up to 20 cm (8 in) in diameter, formed when the turbidity current of the initial breach simply collapsed, depositing those sediments nearly instantaneously.

Nichols (1999, p. 58, parentheses in original) had stated that "in the context of geological time, turbidites deposit 'instantaneously.' The time taken for the thin layer of suspended sediments to be deposited on the top of the turbidite is many orders of magnitude longer (months to hundreds of years)." That conclusion does not appear valid for the Katrina splay sequence. Instead, Layer A appears to have been "abundant particulate matter in suspension" in which "motion imparts turbulence" (McLane, 1995, p. 78). That situation was extremely short-lived; there is no segregation of clasts or graded bedding, and deposition appears to have been immediate, followed quickly by laminar deposition in more regular flow with superimposed storm surge waves. Layer D, the uppermost unit, is also distinct from the underlying laminar couplets. It contains no visible sand. It is largely clay but lacks the clay balls of lower layers. Nelson and Leclair (2006, their figure 7 caption) describe Layer D as follows: "Darker material consists mostly of a wide size range of clay pellets."

Using the location map (Figure 7), we can examine the details of the bedding at several points. At point W (Figure 8), Layer D is approximately 12 cm (4.8 in) thick, as measured just to the left of

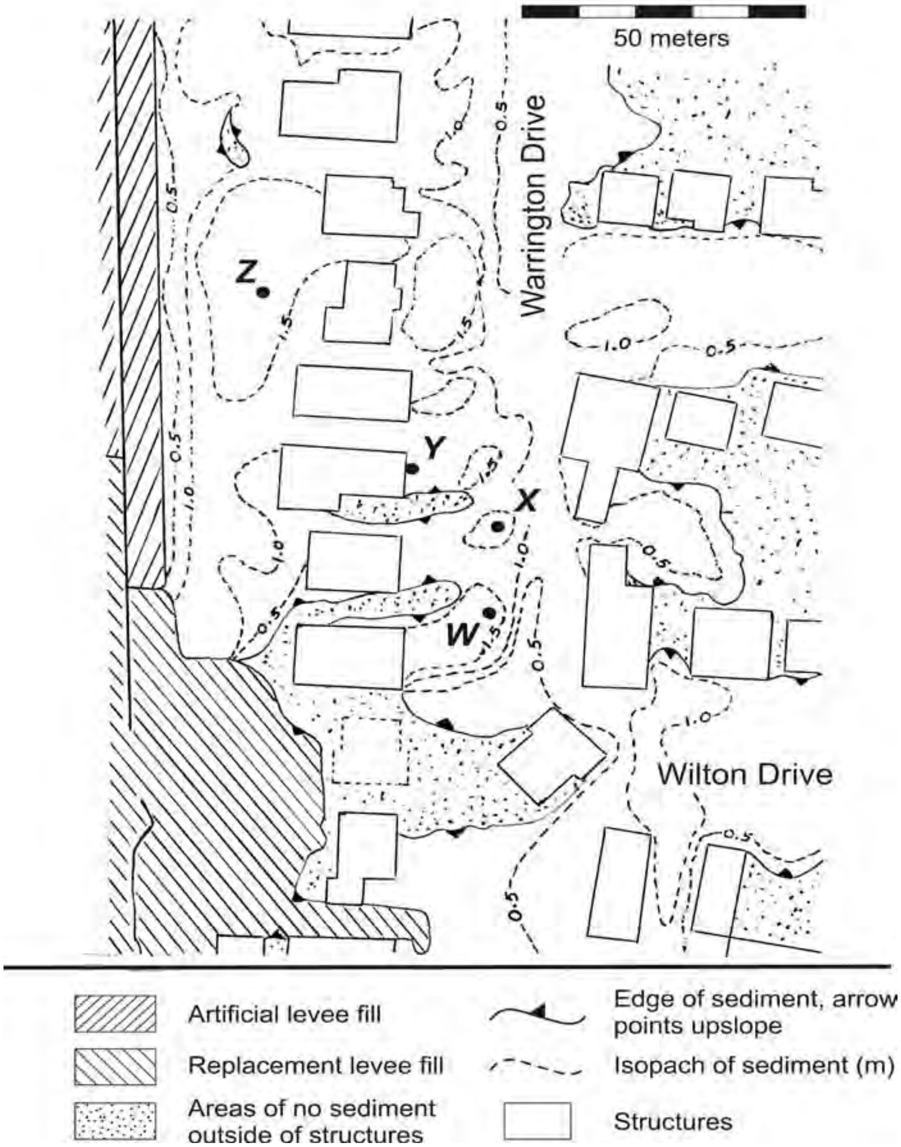


Figure 7. Map showing sediment depth distribution by isopachs in the immediate area of the levee breach. Points W, X, Y, and Z correspond to photos of sediment cross sections. After Nelson and Leclair (2006, figure 4).

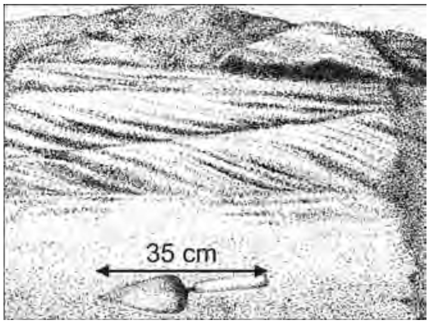


Figure 8. Vertical cross section parallel to flow at Point W showing lapping layers of cross bedding, sublayer B8, near the top of the section. Modified from Nelson and Leclair (2006, figure 7C).

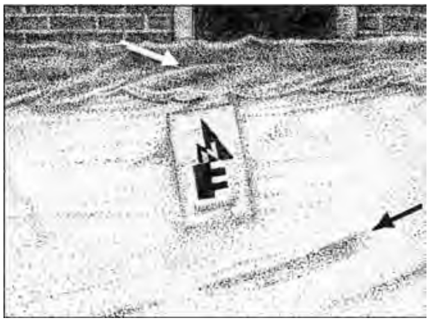
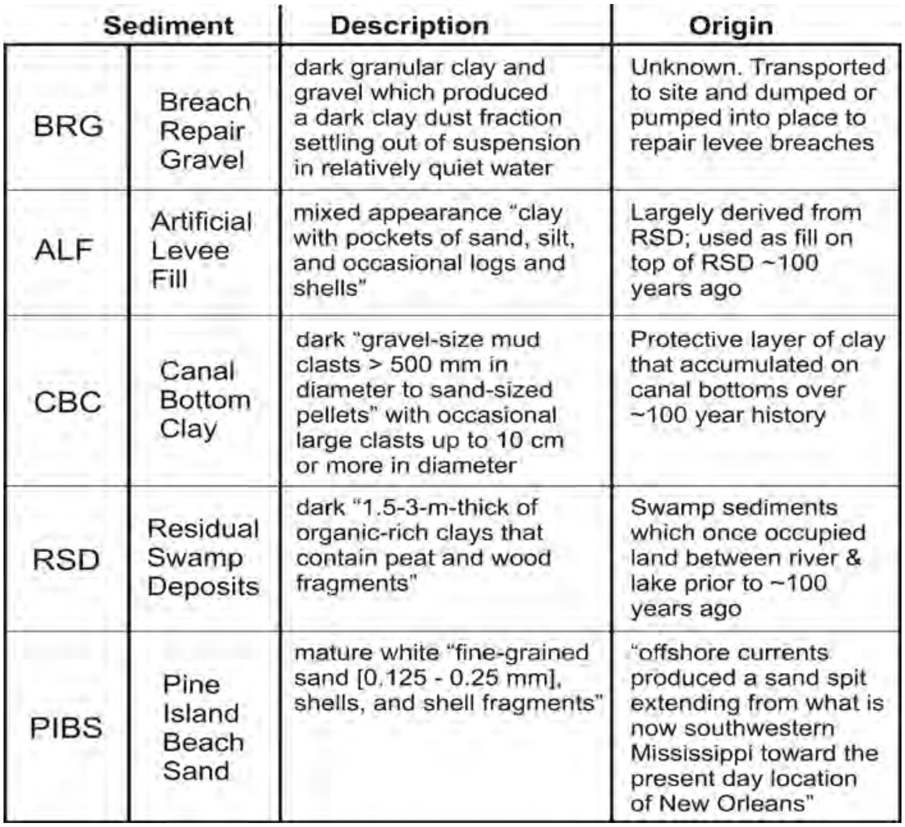


Figure 9. Vertical cross section at point Y on the front porch of house, showing ripples with clay coating (white arrow) and clay drapes in cross beds (black arrow). Modified from Nelson and Leclair (2006, figure 7D).



Sediment		Description	Origin
BRG	Breach Repair Gravel	dark granular clay and gravel which produced a dark clay dust fraction settling out of suspension in relatively quiet water	Unknown. Transported to site and dumped or pumped into place to repair levee breaches
ALF	Artificial Levee Fill	mixed appearance "clay with pockets of sand, silt, and occasional logs and shells"	Largely derived from RSD; used as fill on top of RSD ~100 years ago
CBC	Canal Bottom Clay	dark "gravel-size mud clasts > 500 mm in diameter to sand-sized pellets" with occasional large clasts up to 10 cm or more in diameter	Protective layer of clay that accumulated on canal bottoms over ~100 year history
RSD	Residual Swamp Deposits	dark "1.5-3-m-thick of organic-rich clays that contain peat and wood fragments"	Swamp sediments which once occupied land between river & lake prior to ~100 years ago
PIBS	Pine Island Beach Sand	mature white "fine-grained sand [0.125 - 0.25 mm], shells, and shell fragments"	"offshore currents produced a sand spit extending from what is now southwestern Mississippi toward the present day location of New Orleans"

Table I. Sediment sources for the Katrina splay deposits. All quotes from Nelson and Leclair (2006).

the high point at the top center of the photograph. Point X (Figure 5) shows Layer D at 10 cm (4 in). At Point Y (Figure 9), Layer D has thinned to less than 1 cm, just a dusting clinging to the surfaces of the top ripples. At Point Z (see Nelson and Leclair, 2006, figure 7B), Layer D is only a few cm thick. Thus, Layer D thins dramatically away from the breach. As the last sediment pulse, it appears that most of its sediment was carried as suspended load. The morphology of the dark sediment on the surface of the top ripples (Figure 9) suggests it was emplaced as water drained vertically down through underlying sand bodies, perhaps by settling after the flow equalized or during later pumping. In either case, it is characteristic of sediment deposited in the absence of a current, being thin and conforming to the surfaces of underlying bedforms. It thus suggests that the current had ended prior to its deposition. The only indication of a current velocity change is the ripples themselves superposed over the laminar layer. The only sediment that arrived after the current had stopped and would have dispersed from the force of being dumped into the water would be the breach repair gravels (BRG).

Repairs on the 17th Street Canal took place 4–7 days after the hurricane struck (Thursday, September 1 through Monday, September 5, 2005) (Timeline, 2006, pp. 8–9). They began by closing the lake end of the canal to cut off as much current as possible. Since this canal was on the western edge of the flooding (Figure 1), the breach was accessible by road on the non-flooded side of the canal. Breaches on both sides of the London Avenue Canal caused it to be surrounded by floodwater. There is no account of the repair procedure for this canal, so I can only assume it was much the same, either concurrently or immediately after the 17th Street Canal. Given the lack of access, the former would have required barges to transport the breach repair gravel (BRG).

Based on the dispersal of the settling fraction of the BRG in quiescent waters, the breadth of the bedforms suggests the BRG sediment was dry. Wet clays would have had more cohesion, producing less suspended load. Dumping or pumping BRG into standing water would cause both turbulence and a radiating current from the point of impact. Part of the sediment would go into suspension, moving outward as a turbidity current for a short distance before collapsing. This would account for the varying thickness from Points W to Y, where it essentially vanishes, showing the collapse occurred between points X and Y. The absence of a wider settling pattern is a good indication that no area-wide current was circulating during settling. With the recognition of the occurrence of BRG, the number of distinct sediments is five (Table I), accounting for all observed sediment (Figures 5, 8, and 9).

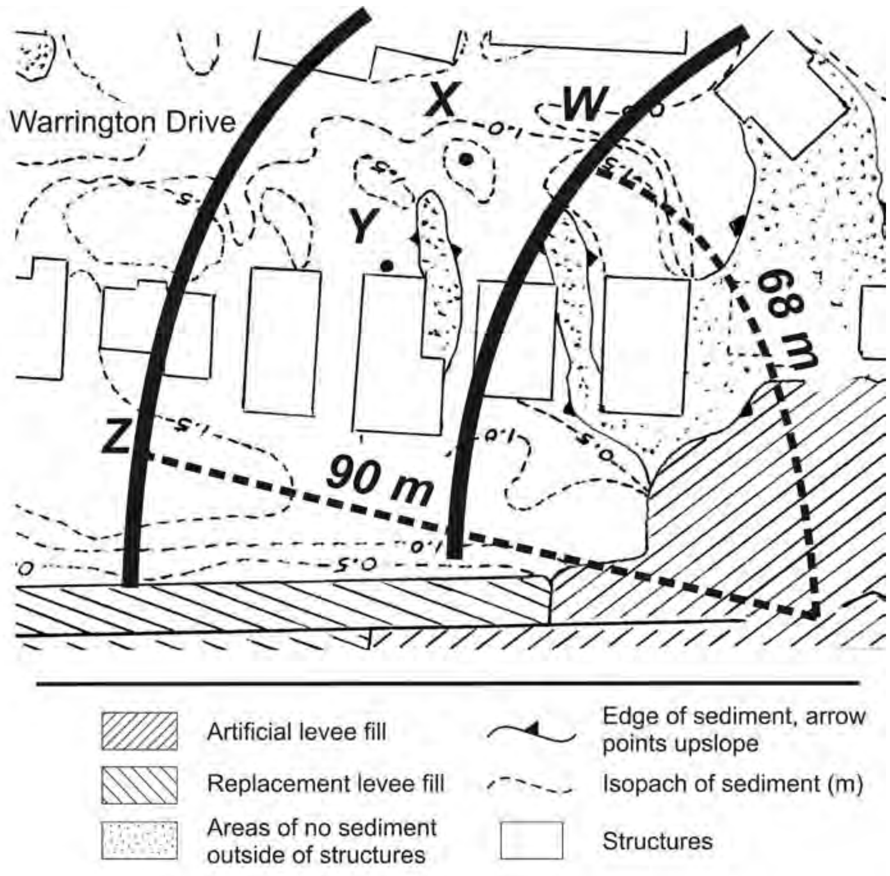


Figure 10. Distance of 68 m to W would produce a semicircular arc of 216 m, and to Z (90 m), an arc of 283 m, an increase in distance of 20% that flow energy is spread across.

Energy in the Sediments

A characteristic of splay geometry is the rapid dispersal of flow over the fan-shaped delta. Was this seen at the Katrina splay deposits? The current was powerful at the breach. At 38 m (125 ft) away, the pressure was sufficient to tear a house from its foundations and transport it another 35 m. It would probably have gone farther, had it not lodged against a tree (Nelson and Leclair, 2006). Including rotation, its rear corner traveled 64 m (Figure 7). At Points W and X, 80 m (262 ft) and 104 m (341 ft) from the breach, respectively, the current retained sufficient strength to transport cars. Sand beneath them indicated that they were suspended in the current for at least a short time (Nelson and Leclair, 2006). Though no mention is made of the distance they moved, one photo (Nelson and Leclair's figure 5C) shows vehicle roofs regularly spaced, not stacked against a barrier. Thus, it is unlikely that the cars moved as far as the house. Nelson and Leclair (2006, p. 3) believed they "had been floating for some time." But given sufficient current to lift and transport cars, would it not have moved them farther? If not, how did the sand get beneath them?

Perhaps the answer is the timing of the events. If Layer A formed almost instantaneously, the cars would not have to have remained buoyant very long. The "layer of sand" under the cars likely represents the collapse of Layer A before it reached the moving house (Figure 7). Also, the current remained quite strong for some distance from the breach, as seen in the sediment distribution. A comparison of Nelson and Leclair's figure 5A, looking from Point Z back toward the levee breach to the rear of the house, and their figure 7B, showing the cross section at Point Z, compared with my Figure 5 reveals that bedforms remain quite similar, although Point Z is about 90 m (295 ft) from the breach, while Point W is only about 68 m (223 ft) away. Using these lines (breach to points) as radii, the circumference of the resulting semicircles would grow from 216 to 283 m (709–928 ft) when obstructions are taken into account, an increase of about 20% (Figure 10). Similarity in bedforms over this distance suggests that the total energy in the current was sufficient that the velocity did not decrease appreciably for some distance. When energy did drop, flow depth decreased so that the velocity was maintained and the bedform did not change. This is the expected relationship between kinetic energy (Froude number), flow velocity, and depth.

Another factor in the current behavior was the presence of obstacles (e.g., houses, cars, walls), which dramatically influenced sediment thickness. In the area around the dislocated house, erosive zones formed between the levee wall and the first row of houses to the west, between the second and third houses. According to Nelson and Leclair (2006, p. 3), the obstructions "created high flow-velocity zones capable of transporting all available material." West of the first five houses (Figure 7), sediment thickness varies in a distinct pattern, though one not clear on the isopach map because the provided elevations are not at a fine enough scale to define the ridges visible in the photographs. Nelson and Leclair (2006, figure 5A) show two ridges parallel to the houses and levee; one ridge near the houses, the other near the levee. Between them is a thin zone. This depositional pattern is reflected in the laminar bedforms spread over the area, which were built roughly parallel to a continuously flat lower surface and rolling ridged surface on top (Nelson and Leclair, 2006, figure 7B). This depositional pattern suggests local variations in current velocity, with greater speed in the center of the temporary channel and along the levee, keeping material in suspension, but decreased energy toward the houses as shown by the ridges of sediment. This type of thickness variation also occurred along Wilton Drive (Nelson and Leclair, 2006, figure 5E), where sediment was preferentially deposited in a ridge along the north side of the street, the main channel in its center allowing less deposition.

Therefore, the major factors influencing sedimentation were: (1) energy dispersal as the current exited the breach, (2) formation of temporary high-energy channels, and (3) local obstacles. The area of highest energy was near the breach—an area that maintained supercritical flow—as shown by the zones barren of sediment (Figure 7). The first sedimentation occurred in the flow shadows between the levee and the houses and about 125 m (410 ft) downcurrent (Nelson and Leclair, 2006), as the flow expanded out into the open areas of the neighborhood. This was much closer than the 800 m (2,625 ft) at the 1993 SNY Island levee breach during the upper Mississippi Valley flood (Gomez et al., 1997), but both locations show deposition in a horseshoe-shaped rim, indicating the arc where flow transitions from supercritical to subcritical and allows sediment to be deposited. Those similarities suggest the same kind of focused power current. The SNY Island breach had a stronger head, leading to the larger eroded area in front of the breach.

Open flow paths, unlike those around obstructions, affected deposition. That was a function of the dependence of high-velocity laminar deposits on relative turbulence and sustained energy from the pressure head. Any time energy is dispersed, as in flow "leaking" perpendicular to the main current between the structures on Wilton Drive, sufficient carrying capacity dropped precipitously, and significant sedimentation did not continue past those points.

This suggests:

- Entraining a large amount of very fine sand and depositing it in a regular, rhythmically varied pattern requires a large, regular, rhythmical source of energy, a condition not typical to natural processes. In this case, that source was likely the storm surge waves.
- Constant bedforms over any distance produced by constant unidirectional flow require an adequate and constant source of energy (head pressure or slope).
- Patterns of sediment thickness indicate energy patterns in the flow. Obstructions were a primary source of these variations at the Katrina canal breaches.

Katrina Splay Deposits Versus Conventional Thinking

Traditionally, a crevasse is a break in a glacier or levee, and a splay is a sloping deposit of sediment deposited from that opening. These deposits resemble alluvial fans and are typically a part of river deltas. Splays are seen as relatively benign accumulations of sediments produced by infrequent, random sedimentary events. Nichols (1999) spent a full chapter describing crevasse splays on various types of deltas, and the expected sequence of strata in the facies. Despite an apparent order in the Katrina deposits, the facies approach seems remarkably inappropriate (Walker, 2007).

Since crevasse splays often occur on deltas, their sedimentary sequence is similar to an estuarine or deltaic setting. But Walker (2007) showed how facies interpretations could be misleading, when he noted how the virtually-instantaneous Katrina deposits mimic the expected sequence "of different environments over long periods of time," with which he produced a "hypothetical and erroneous depositional environment for the sedimentary section." He added: "It is apparent that the whole deposit of sand was laid down quickly… and the different characteristics observed in the vertical section represent changing flow conditions" (Walker, 2007, p. 9).

The Katrina splay deposits appear to have had quite a different origin from those of the standard delta scenario. There, the substrate would be a mud flat (Nichols, 1999). Occasional breaches would result in alternating layers of mud and sand, sand representing active sedimentation and mud, passive periods.

Geologists consider clay drapes to be another example of this alternating active/passive cycle. These features appear when clay settles on the lee slope of cross beds in a sandy deposit, like those in the Katrina splay (Figure 11, Figure 5, sublayer B8, and Layer C). Nichols (1999, pp. 138–139, brackets added) considers clay drapes to be an indication of:

> high or low tides when the current is changing directions, there is a short period when there is no flow. Whilst the water is still, some of the suspended load [clay] may be deposited.

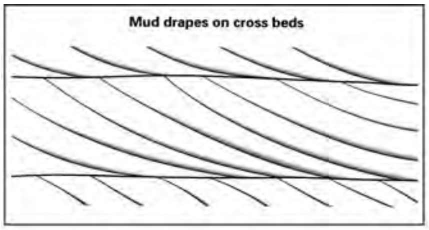


Figure 11. Clay drapes after Nichols (1999, his figure 11.6). Note regular pattern of clay layer on top and lee slopes of cross-bedded sandstone.

> When the current becomes stronger during the next tide the suspension deposit may not be removed because of the cohesive nature of the clay rich sediments.

When clay drapes cover a large flat area, like sublayers B1, B3, and B5, they are ascribed to tidal point bar deposition, where "the episodic nature of tidal flow allows fine materials to come out of a suspension on the gently sloping bar surface. Alternations of sand and mud on bar deposits produce a pattern of bedding referred to as *inclined heterolithic stratification*" (Thomas et al., 1987, cited in Nichols, 1999, p. 164, emphasis in original). In both cases, geologists assume that clay represents quiescent flow between periods of active sedimentation. Do the Katrina clay drapes support this idea?

Both drapes and inclined heterolithic stratification are found in the Katrina splay deposits. Figure 5 shows clay drapes on the lee slopes of B8, while B2, B4, and B6 would readily be interpreted as "inclined heterolithic stratification." Though they look like tidal reworking, the actual sequence of events contradicts that theory, and Nelson and Leclair (2006) cannot support their suggestion of reworking with evidence. The nature of the current flowing from the breach suggests otherwise; there were no redeposited sediments in barren areas, suggesting little to no reworking or resuspension of sediment. Furthermore, the sedimentary episode occurred so quickly (maximum 46 minutes) that there was not time for the classic active/passive cycle.

Clay drapes (Figure 11) also suggest the prevalent theory is wrong. It is well established by flume studies that when migrating dunes formed by high-velocity currents produce upper-regime bedforms, that a velocity decrease causes an abrupt change from dunes to ripples. Figure 9 shows a thin layer of clay adhering to ripple surface. If this were from the BRG, it would be a true clay drape settling from quiet water.

Other bedform changes can occur without a significant change in velocity. Laminar flat beds can grow into dunes in some cases with a significant increase in depth. Although ripples, dunes, and antidunes can collapse into laminar layers when velocity decreases below that needed to support flow separation, it appears that none of Katrina's sublayers exhibit characteristics of this phenomenon. Nichols (1999) gives no hint of a transition through collapsing bedforms to clay drapes, nor does his one lithified field example support it (his figure 11.7).

Likewise, Katrina splay sediments (Figure 5) show no transition through collapsed bedforms to clay drapes in their sequence of laminar sand and clay beds. In B6, laminar flat beds precede and follow the clay layer, indicating continued high flow. Also, B2 and B4 reveal laminar flat beds intermixed with the clay layer. B8 shows the same thing; both near the bottom and top, cross bedding precedes, follows, and is mixed with clay drapes. If the splay deposits do not represent successive facies (Nichols, 1999), as suggested by Walker (2007), then Layers A through C (Figure 5) were all laid down in one unidirectional current of relatively constant flow (from the excessive head), interrupted by regular storm surge wave pulses. The clay in the splay is in contrast to the pre-Katrina canal bottom clay, which accumulated slowly over many decades. But the sequence of strata beneath the canal are dissimilar from the splay deposits that show clay interspersed with sand, all in bedforms consistent with the observed high-energy flow through the breach.

Thus, Layer A is not a prodelta mud that McLane (1995, p. 201) suggested underlies the typical crevasse splay, where "much of the mud is deposited out of suspension." Even though mostly clay by composition, it fits better with the research of Schieber et. al. (2007), who demonstrated through flume experiments that clay and mud can be deposited in currents, not requiring low-energy conditions. Another argument for continual high-energy deposition is found in the presence of clay balls throughout the sequence—at least three exceeding 10 cm in Layer A, and another of similar size in B6. Even though most of the clay balls are smaller than a cm (Nelson and Leclair, 2006), some in the sand size range and others as flakes or floccules, none were deposited in quiescent conditions.

Clay drapes are common in the cross bedding of B8 (Figure 5), visible as gray shadows between the bedding planes. In Figure 8, the cross bedding is obvious, but many of the foresets appear to have a gray shadow under them due to an irregular surface. These gray areas are not merely shadows but are ubiquitous clay drapes.

Figures 8 and 9 show clay drapes as a common part of the bedforms. This suggests that the clay was deposited at velocities and depths similar to the sand, as was seen by Schieber et al. (2007). This is not surprising as they reported that the floccules under the scanning electron microscope revealed "a 'bumpy' surface pattern of closely packed ovoid bodies (0.2–0.6 mm in size)" (Schieber et al., 2007, p. 1761). That irregular surface resulted from the random aggregation of 1–5 µm clay particles. This tendency for clay to form ovoid bodies similar in size to fine sand suggests that both clay and sand would act similarly in deposition. A close study of the clay cross beds (Figures 5 and 8) shows two differences between foresets created by sand and those by clay. Most clay foresets do not reach the top of the dunes, and most of them fatten as they reach the tangential point at the bottom of the lee slopes. Again, these differences show that although both sediments were laid down at the same velocity, the clay ovoids responded slightly differently to flow separation—possibly due to a small difference in specific gravity or to the rougher surface of the clay balls, making them more mobile than sand. That would explain why they were swept off the dune crests and cascaded farther down the lee slopes. Another possibility is that clay ovoids may have a lower angle of repose.

But clay drapes in B8 were deposited just as rapidly as the sand. There were no active/passive cycles in the current velocity happening rapidly enough to account for all of the alternations in B2, B4, and B6. But the purity and thickness of some clay drapes suggest the very rapid formation of "floccule streamers," which can occur at a velocity over 0.8 m/s and a density of about 5% solids. Schieber et al. (2007) showed the slow formation of these streamers at 0.5 m/s and 0.0003% to 0.2% solids. Floccule streamers are large aggregates of floccules that form spontaneously by cohesive forces in suspension. Each streamer may settle out as a single unit or combine to form larger clay drapes. Unfortunately, Schieber et al. (2007) gave no information for higher solids concentrations, and I can only cautiously speculate based on the evidence from the available photographs.

Though the clay drapes appear significantly darker than the sand cross beds, they may not be pure clay. Schieber et al. (2007) suggest a shrinkage rate of 85% for pure clays. In working with ceramic clay, where a significant amount of sand or other filler has already been added to the clay to control the shrinkage, a clay vessel may still shrink 10–20% in the drying process prior to firing. The pictures give no indication of this high shrinkage in the clay bedforms, suggesting the floccule streamers collected a significant fraction of sand that made them more stable.

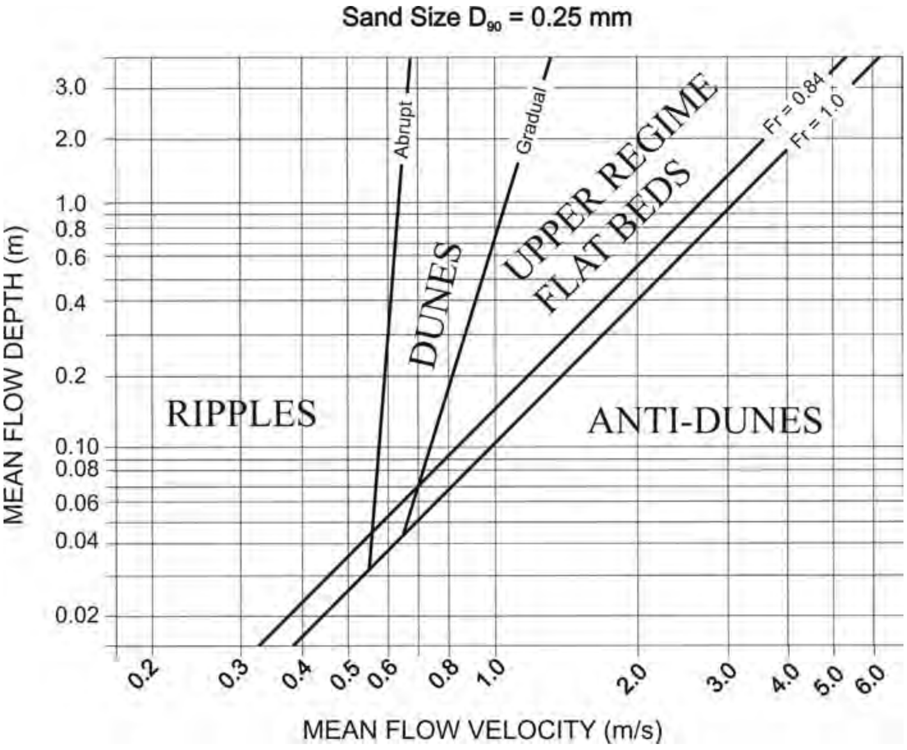


Figure 12. Logarithmic depth velocity diagram for 0.25 mm sand, showing transition lines between stable bedforms. After McLane (1995, figure 5.14).

Examining the transition from flat beds to cross beds, B7 to B8, we see more evidence for constant flow. Cross beds start small, as seen prominently in Figures 5 and 8, and the change in bedform can be attributed to changing water depth, not velocity (Figure 12). Clay torn from the canal bottom represents continuing storm surges. Thus the clay shows that no decrease in velocity was taking place. The passing of each wave would raise the water level in the canal and propagate out into the neighborhood with little drop in depth or dispersal of energy, even after depth in the neighborhood reached the mean canal elevation. Perhaps it was near this time that the additional portion of the steel sheeting failed. Figure 6 shows some secondary opening of the breach after the initial failure (Figure 13).

Whatever the mechanism causing the change, the added water depth was sudden, and the resulting sedimentary bedforms accreted to their maximum height. The change from flat beds to cross beds could have resulted from an abrupt flow depth increase such as at 0.85 m/s in Figure 12, where at 0.2 m (6 in) deep, the bedform would be flat beds and would continue as such up to 0.5–0.6 m (1.6–2 ft) deep. When depth reached 0.8–1.0 m (2.6–3.3 ft), flow separation could have taken place and dunes would have started to form.

In Figure 8, the tangential contacts at both the top and bottom of the lee slopes of the dunes are visible. Since the top of the dune still displays the

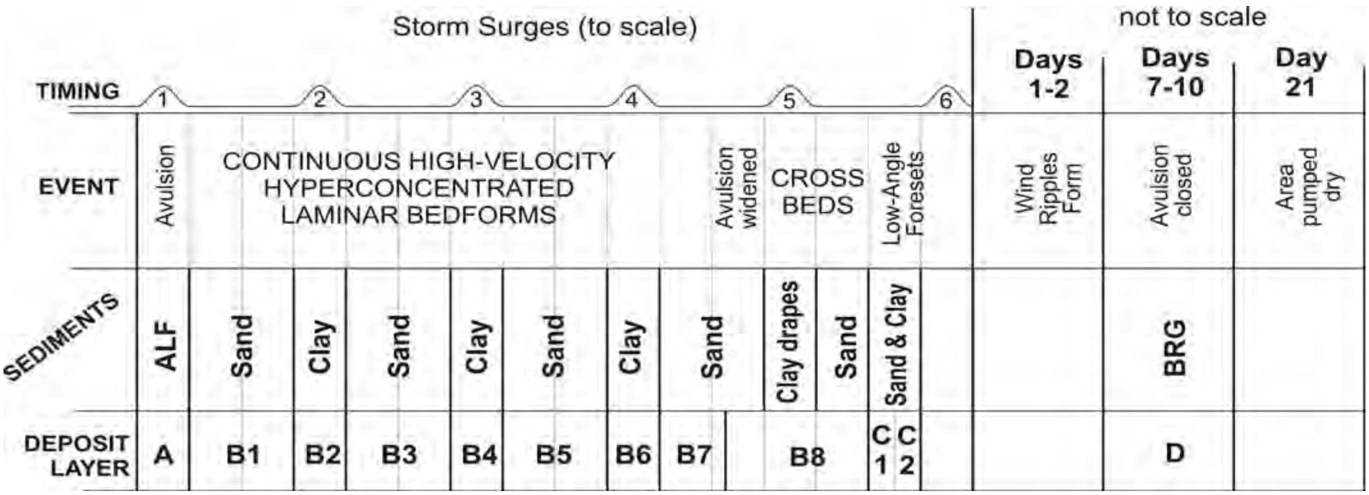


Figure 13. Timeline of significant events during splay deposit and development. Dotted lines under "storm surges" represent 7–10 second intervals. "Avulsion" may have required one full storm surge to develop. This timeline only documents the arrival and deposition of the sedimentary layers, from ALF (artificial levee fill) to BRG (breach repair gravel).

tangential transition from the stoss side of the dune over the crest and onto the lee slope, it is clear that the stoss side experienced little or no erosion. The diagonal line rising from left to right was a relatively stable stoss slope growing in elevation as the lee slope moved forward by settling sand from the suspension fraction in the separation zone with little or no contribution of the bed load fraction from the stoss slope.

Another indication of rapid deposition is the absence of evidence for erosion within the layers. This is shown by the tangential contact at the bottom of the lee slope, which indicates no erosion into the lowermost flat beds or the developing cross beds when the upper layer was forming and reaching the pinch out spot toward the upper right-hand edge of Figure 8. Eventually the cross-bedded layers of B8 were overlaid by Layer C1, which in both Figures 5 and 8 appears as a very low angle foreset. It appears that the relative depth dropped again. This is reasonable since the depth line of Figure 12 slides down past the transition line for upper-regime flat beds. The slight slope to the beds in Layer C suggests the depth remained in that transition zone. Such flat beds will deposit laminar layers on slopes up to the angle of repose (30°-40° for sand) (Berthault, 2002), and distinguishing between low-angle cross beds and angled high-velocity flat beds is difficult. At any rate, these cross beds were not formed by the typical advance of dunes. Instead, they grew as tilted high-velocity flat beds on an inclined plane in the separation zone of the lee slope, limited in height by water depth.

Given what we know about the breach, it is likely that after the catastrophic deposition of Layer A (Figure 5), the current remained essentially constant, with minor depth fluctuations through deposition of Layer C. Although clay drapes are more prominent in B8, they are clearly present as early as B1 and found in the intervening sublayers. Clay concentrated in B2, B4, and B6 is an artifact of the hydrodynamics of the continuous high-flow conditions, not decreases in velocity.

Abundant clay drapes in B8 suggests a fifth energy pulse that entrained a significant amount of clay. The higher proportion of clay at Point W (Figure 8), closest to the breach, and the lower amount at Point X (Figure 5), and the near absence of clay at Point Z may be connected to the decreasing carrying capacity of the flow for floccule streamers as the current dispersed.

An anomalous example of clay drapes is found at Point Y (Figure 9). The direction of slope appears reversed. But this was caused by local variations in the current in a partially enclosed porch. (Note: the angle of the mud drapes compared to the ripple crest shows that the cut surface was not parallel to current flow.) Another clay drape is at Point Z, adjacent to the top of the trowel handle visible in Nelson and Leclair's (2006) figure 7B. The cross section is perpendicular to flow, and the dark, discontinuous lines in the left half of the figure are clay drapes seen head on.

Overall, the sequence, from Layer A through C, appears to be a continuous deposit marked by 5–6 energy pulses. If these pulses occurred as rapidly as every 20–30 seconds, then this entire sequence was deposited in 2–3 minutes. However, this time frame for deposition does not imply that the entire neighborhood basin was filled with water in that same time span. Deposition took place under a relatively shallow flow of water that projected upwards above the fringe of the deposit no more, and probably significantly less, than it had near the evulsion where deposition began. For the water level to reach maximum elevation across the entire neighborhood basin may well have required closer to the 46 minutes reported for flooding the Lower Ninth Ward. The limited extent of deposition (about 400 m) indicates the limit of sediment transport by the hyperconcentrated flow.

Once more, the lack of significant sediments in the areas of supercritical flow during the original period of peak deposition suggests wave propagation continued with the same energy needed to maintain supercritical flow in those areas until the sediment load had diminished. The full height of two 3-cm sublayers in C indicates that nothing is missing. Erosion or reworking of the already-deposited sediment in this continuing flow did not occur, but the current did continue for some period of time afterwards.

This is supported by escape holes cut through the roofs of local houses—there was no other means of escape, even minutes into the flooding event. Once the water began to flow into the neighborhood, it continued until it quickly reached its maximum of 1.9–2.4 m (6.2–7.9 ft).

This leads to the following conclusions:

- A continuous sequence of sediments requires a continuous current; velocity changes will be reflected by bedform changes. Absent this, no velocity shift appears evident.
- Naturally occurring, low-velocity currents, such as tides, do not provide an adequate model for catastrophic events.
- The Katrina bedforms appear continuous, including the clay drapes, absent evidence of current variations. Repetitive cycles are accounted for within the context of constant, unidirectional flow by energy pulses from storm surge waves.
- If these waves had intervals of 20–30 seconds, and six or less are seen in the recurring cycles, then the entire sequence, 1.6–1.8 m (5.2–5.9 ft), was deposited in 2–3 minutes, a rate of 0.6–0.9 m/minute.

Bedforms

Nelson and Leclair (2006, p. 3) described the Katrina splay bedforms as:

> overlying a massive clayey-sand layer… planar strata were dominant and continuous…. Low-angle strata… reflected the shape of the ridges surfaces…. Medium-scale cross-strata overlay planar strata only along Warrington Drive…and small-scale cross-strata were largely absent, except in protected areas, such as houses, porches…. Spectacular cases of climbing dunes were seen on obstacles, such as cars…. Cross-stratification around obstacles indicates different flow directions."

Later they note that the "planar strata…indicates that an upper-stage plane bed, and hence, an upper flow regime, prevailed during much of the deposition" (Nelson and Leclair, 2006, p. 3). The difference between these deposits and "those observed in modern sandy crevasse splay deposits, where, although planar strata is very common, climbing-ripple cross-strata and medium-scale cross-strata (from dunes) are also commonly observed at the top and in crevasse channels, respectively" (Bridges, 2003).

This agrees with the well-defined, cm-scale planar strata in Figure 5, but not as well with the structure of the mm-scale layers. While B1-B7 show a regular pattern of flat, alternating beds of sand and clay, continuous parallel to flow, the sand and clay laminae in the mm-scale beds are unusually discontinuous. Curiously, planar strata perpendicular to flow are also discontinuous. The laminae are patches or smears of one type of sediment overlapping other patches or smears of other types. They combine to form an irregular but flat stratal unit—much like small blankets spread out into a random pile with their long axes arranged parallel.

We cannot understand the planar strata without an explanation for this arrangement. "Planar strata" is a descriptive term used for a variety of bedforms common in the rock record, which, when lithified, form relatively flat bedding surfaces. They are often mined for flagstones for paving and building (McLane, 1995). There are three specific sets of flow and sediment conditions under which flat beds form. Each of these is specific enough to be differentiated by keen observation. These include: (1) low-regime flat beds, (2) upper-regime flat beds, and (3) antidunes (Figure 14). Confusing these will drastically confuse interpretation of flat beds found in the rock record.

Lower-regime flat beds occur only in medium to coarse sand, > 0.7 mm (Nichols, 1999). Grains protrude above the viscous sublayer, generally no more than 0.6 mm thick. In that layer, friction exceeds turbulence, and streamlines are smooth. In a large channel, the bottom is the only surface to produce turbulence, which originates at the upper boundary of the viscous sublayer and moves up into the current. Grains exceeding its thickness create turbulence and will eventually cause flow separation. Moving bed load during sediment accretion create perturbations that cause additional grains to accrete and nonlaminar bedforms to grow.

As sands finer than 0.6 mm accrete, the viscous sublayer moves up with the new channel bottom, and flow separation will occur above the location of a perturbation. This causes the formation of individual ripples and a rippled bedform. In medium to coarse sand, continuous flow separation cannot take place (Nichols, 1999). When accretion begins at a perturbation, a ripple will start to form at the first incipient flux

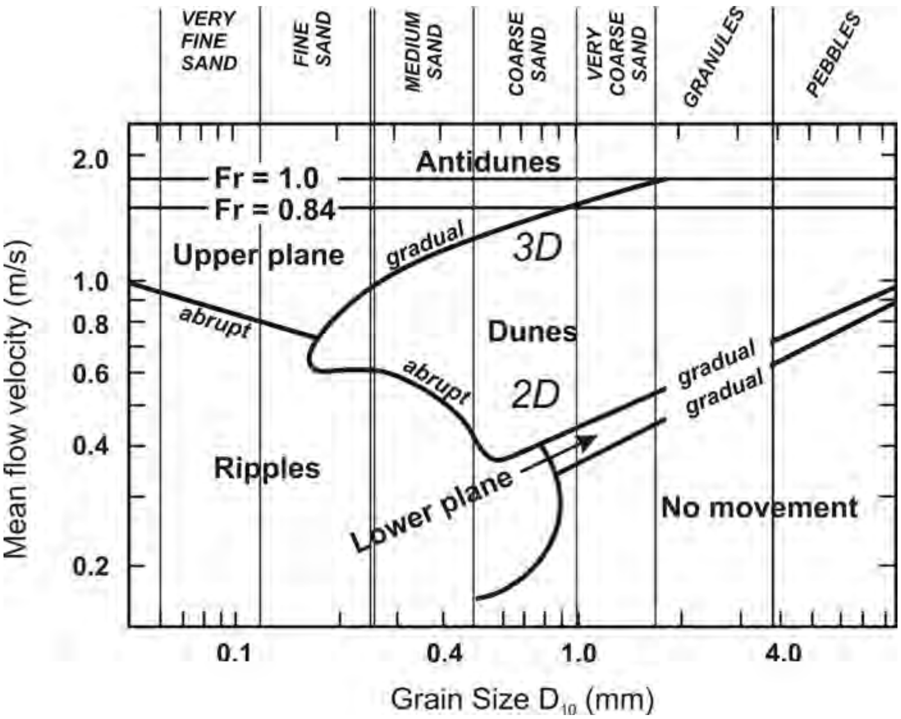


Figure 14. Bedform stability field by grain size classifications showing the bedform progression, up and down, for velocity increases and decreases. From McLane (1995, figure 5.15).

of flow separation, but then turbulence will overwhelm and capture the motion and the incipient ripple with collapse (McLane, 1995). This constant washout of the ripples bedform produces relatively flat beds with an irregular, wavy internal structure (Barwis and Hayes, 1985). This results in lower-regime flat beds not having a continuous, flat laminar internal structure and being poorly defined at their parting surfaces (Nichols, 1999). By contrast, there is much better definition in flat beds originating in a high-flow regime due to the presence of primary current laminations of low-form elongate ridges and furrows parallel to current direction (Nichols, 1999).

As the sweeping high-shear turbulence parallel to flow is transferred down into the viscous sublayer, the resulting drag of the lowest streamline may not be strong enough to lift individual grains of sediment, but it does pull more mobile fluid particles up from the intergranular spaces, and this fluid is replaced by fluid pulled down into the viscous sublayer, producing Taylor-Gortler vortices (McLane, 1995) that produce the striations of the parting laminations.

Distinct parting surfaces also form in high-regime flat beds due to separation between bed load and suspended particles. Julien et al. (1994) document the extensive speculation about the causes of parting surfaces. McLane (1995, p. 84) even went so far as to speculate, "Bedding planes take more time to make than the beds themselves." This is contrary to Julien et al. (1994), who demonstrated that both bed and parting surfaces form simultaneously, and at the same rate, although at different locations. This provides separate laminae of the larger particles, which are rolled or saltated into position, while suspended fines, which have a constant fall velocity even in fast currents, land on top of the laminae of heavier particles. It is the fine sand surface that varies shrinkage, due to a greater grain surface-to-volume ratio with weaker intergranular adhesion. This results in parting surfaces.

Third, flat beds are formed from antidunes. Often associated with visible small surface waves forming directly above the dune front, antidunes are also referred to as inline waves. They grow either upcurrent or downcurrent by depositing sediments on either the stoss or lee slope of the dunes. Occurring at a minimum Froude number of 0.844 to 1.0 (Kennedy, 1963), antidunes form within the range of supercritical flow. This flow fosters turbulent breaking waves on the surface. As the antidunes grow taller, the inline wave's crest rises until it breaks. When the inline wave breaks, turbulence is directed downward, and the dune front collapses into a flat bed (McLane, 1995). This produces the same irregular, wavy internal structure as the washed-out ripples that form lower-regime flat beds (see figure 7; Barwis and Hayes, 1985).

Which of these three flow conditions produced the Katrina splay deposits? The mm-thick layers do not show the washed-out internal structure typical of low-velocity flat beds or antidunes. But, neither do they show the obvious lamination expected of upper-regime flat beds. Instead, they exhibit anomalously discontinuous laminae. Also, the only ripples are those found in the uppermost layers (Figure 9), and since lower-flow flat beds form at velocities too low to produce ripples, they are likely not the "planar strata" of that flow regime. And, although the flow reached supercritical status regularly, Point X (Figure 5) shows supercritical flow only at the initial levee break and shortly afterwards. A careful study of B1 (Figure 5) does not show any more reverse-sloped cross bedding here than in other sublayers, making an antidunes origin unlikely. Therefore, I conclude that the "planar strata" are upper-regime flat beds based on the mathematical calculations.

τ_*	S	d_{50} (m)	d_{max} (m)	density	% solid	τ_0 (N/m²)	h (m)	Manning			Logarithmic		
								n	V (m/s)	Fr	k	V (m/s)	Fr
0.055	0.00375	0.00025	0.03	2.00 g/cm³	0.05	15.41	0.40	0.016	2.13	1.08	0.0017	2.41	1.21
					0.09	14.76	0.37		2.03	1.06		2.30	1.21
					0.20	12.48	0.29		1.72	1.02		1.97	1.16
					0.30	11.35	0.24		1.52	0.99		1.75	1.14
				2.25 g/cm³	0.05	19.25	0.49		2.45	1.12		2.73	1.25
					0.09	18.44	0.45		2.31	1.10		2.60	1.24
					0.20	16.21	0.35		1.95	1.05		2.21	1.19
					0.30	14.19	0.28		1.68	1.01		1.92	1.16

Table II. Calculations of flow depth (h) and velocity (V) using both Manning and logarithmic equations showing the Froude number for each combination.

For these hydrodynamic calculations, the following symbols will be used:

γ_s = specific gravity of the solid phase
γ_m = specific gravity of the water/solid mixture based on the percent concentration of solids
d = diameter of the sediment particles
τ_* = dimensionless shear stress for the solid particles
τ_o = critical shear stress for initiating particle motion
h = flow depth
$\overline{V}$ = depth averaged velocity
S = slope steepness factor
g = gravitational attraction

The critical shear stress (τ_o) can be determined using the Shields parameter equation (Julien, 1998, p. 5):

$$\tau_o = \tau_* (\gamma_s - \gamma_m)\, d_{max} \tag{3}$$

A density of 2.65 g/cm³ is used for the fine sand and 2.0–2.25 g/cm³ for the 1.0 cm (0.01 m) clay balls. Though the nature of the clay balls suggests a lower density, they were transported and deposited directly with the sand. This is consistent with the work of Schieber et al. (2007), examining clay flocculation in currents. The Katrina clay balls were both wet and consolidated, so these densities may be close. Since channel-bottom clay erosion was likely caused by energy pulses from storm surge waves, small deviations in density may have negligible effects on calculations.

Lalomov (2007), citing Polyakov (2002), places the boundary between Newtonian and non-Newtonian flow at 9% sediment load, while Julien (1998) gave a range of 5–60% for hyperconcentrated flows. Lowe (1982) places hyperconcentrated flow at 20–30%. Table II provides parallel results for 5%, 9%, 20%, and 30% solids by volume.

The τ_* values given by Julien (1998) for medium sand (> 0.25 mm) is 0.048; for fine sand (> 0.125 mm) the value jumps to 0.072. A mean value of 0.06 is sometimes recommended (Julien, 1998), but not knowing the sorting of grain sizes within the spread and realizing the sediments moved to dunes, which would have happened in 0.125 mm, I chose to use a value of τ_* = 0055 for Table II skewed toward the 0.25 mm grain size.

There is a 7 x 9 cm (2.8 x 3.5 in) clay ball in B6 (Figure 5). It appears to be the largest clast moved following the original breach. But, careful inspection shows that the layers of B6 are actually deflected downwards by the clast; it is likely an outsized clast that fell onto the flow and was rafted on top of the dense sediment layer. This also seems to be the case with the 3 x 5 cm (1.2 x 2 in) rectangular clast embedded in B4 just to the left of the tape measure. The largest clast entrained in the flow is the irregular 3 x 5 cm clay lump in B6 next to the right edge of the picture. The intermediate measurement for the lump, 3 cm is used for d_{max}.

The DuBoys equation (Lalomov, 2007) calculates flow depth (h) from critical shear stress:

$$h = \tau_o / \gamma_m S \tag{4}$$

Nelson and Leclair (2006) propose a slope of about 0.004, but the use of their measurements returns S = 0.00375. This produces flow depths of 0.24–0.40 m. This depth is relatively shallow. A depth of 0.24 m (10 in) on the lower end hardly seems a threat to human life, but the escape holes cut into the roofs indicate such a threat existed. This further supports the rapidity of flooding—46 minutes maximum in the Lower Ninth Ward and only 2–3 minutes for the passage of 5 to 6 storm surge waves.

Using the Manning equation for velocity (Julien, 1998):

$$\overline{V} = S^{1/2}\, h^{2/3}\, n^{-1} \tag{5}$$

Julien (1998) gives the value of the Manning coefficient (n) for fine sand (colloidal) to fine gravel as 0.02. The constant slope of 0.00375 is used for S since Schumm and Khan (1972) noted a strong correlation between sediment load, flow velocity, and slope; slope remained consistent relative to these other parameters in equilibrium conditions. The calculated flow velocity is then between 1.17 m/s and 1.91 m/s.

As a check on the Manning velocities, the logarithmic equation (Julien, 1998) was used:

$$\overline{V} = 5.75\,(\mathrm{g\,h\,S})^{1/2} \times \log\,(12.2\, h / k_s) \tag{6}$$

As dunes are produced in Figure 5, Layer B8, this is a strong indication that the grain size was skewed more towards the upper end of the grain size range, so $k_s = 5.2\ d_{65}$ with $d_{65} = 0.00025$m.

All velocities obtained from the logarithmic equation produce Froude numbers that exceed unity, showing that they are too high. A $k_s = 6.8\ d_{50}$ was attempted without significantly better results.

Examining the Froude numbers for the Manning velocities and considering how many parameters had to be estimated, the most likely conditions seem to revolve around a density for the wet clay of 2.00 g/cm^3 and a range of 20–30% solids. This would confirm that the flow reached hyperconcentrated conditions as defined by Lowe (1982).

We need to understand the deposited thickness laid down by a single energy surge or wave. Were they individual mm thick laminae or thicker sets? McKee et al. (1967) noted the discontinuous nature of the unique beds of the Bijou Creek Flood, mixed with more common sand layers extending the width of the deposits. The latter indicated a current across the breadth of the flood, while the narrow, discontinuous layer demonstrated different flow conditions. He cited sets of laminae "three to four inches thick" that were "bent downward into shallow V's in three places [within one investigative trench]; the nearly horizontal laminae above and below were undisturbed" (McKee at al., 1967, p. 836, brackets added). They concluded that projectile pebbles—possibly launched out of the water—produced the impressions in the existing beds before being buried by more fine sediment. Because the pebbles landed on top of a stack of laminae and left a dented impression in the total stack, but not into the underlying laminae, all layers in the dented stack would have been in approximately the same stage of dewatering while the stack below had already compacted, and therefore, it was too dense to take on the indent. This indicates the laminae were laid down not singularly but in sets.

A second bedform McKee et al. (1967) document from the Bijou Creek Flood that seems to have a bearing on the concept of sets of laminae is convoluted structures. Convoluted bedding seems to be a terminal low-velocity bedform produced when high-velocity currents are suddenly slowed and "sediment was in the condition of quicksand" (McKee et al., 1967, p. 840). As cohesive forces were forming laminae at high velocities, the system experienced a sudden decrease in velocity and was unable to keep the laminae flat. The system pancaked like a high-velocity train suddenly stopping. The convoluted bedding shown in their figures 7 and 9 are sections of tightly convoluted ribbon and broken U-shaped structures, all formed from a set of laminae that appears to have been 7–10 cm (3–4 in) thick in its original flat form. Though no convoluted bedding is present in the Katrina splay deposits, these sets of laminae seem to be the basic structural unit characteristic of hyperconcentrated flow. This suggests that under hyperconcentrated conditions in a high-velocity regime, individual laminae (< 1 cm) are not laid down singly, but instead a multi-cm-thick set is laid down simultaneously. I believe that the 7–10 cm set of laminae documented by McKee in these two instances, constitute a single set separated from those above and below by a very short but significant period of time.

The occurrence of laminae in sets is analogous to Katrina's sublayers B2, B4, and B6—which are 7 cm, 5 cm, and 6 cm, respectively, or a mean of 6 cm. Is this the thickness of the storm surge sets? An examination of the 7 x 9 cm clast in B6 shows that only the lower half of the clay layer is deflected by the clast and the other half of the layer went around it. Because waves occur in a train, with the largest at regularly spaced intervals, B1, B3, B5, and B7, which are primarily sand, represent the train of smaller resonating waves between the storm surges, each leaving a set averaging 3 cm thick.

Rubin and McCulloch (1980, p. 222, emphasis in original) suggested: "The mean height of relatively straight crested sand waves in a train is generally *less than or equal to* approximately 1/6 of the mean flow depth." This 6:1 ratio may apply to other bedforms. Allen (1976) proposed that bedforms never exceed a 6:1 to 8:1 ratio of flow depth to bedform height. If a 3 cm-thick set of laminae is laid down by a single wave, then a minimum depth of 0.18–0.24 m would be required during the deposition of the clay sublayers. This depth is in relative agreement with the 0.24–0.29 m depth obtained in Table II and suggests either the clay density was a little lower or the concentration of solids was a little higher.

In Figure 5, the bedforms change from flat beds to cross beds, back to flat beds, as seen in B7, B8, and Layer C, respectively. This sequence first appears at Point W (Figure 8), where the cross beds are more prominent. The growth of the lowermost cross beds in Figure 8 appears to define the growth on the top and lee slope of a single dune. The top of that growing dune (right edge of photo) is similar in height to the top of another dune (from left); thus it appears that depth limited the ultimate height of the cross beds. If the maximum height of the cross beds in B8 is 20 cm, it would require a flow depth of 1.2–1.6 m to produce a ratio of 6:1 to 8:1. A comparison of elevation from the bottom of B8 at Point W with Figure 3 shows it to be almost equal to mean sea level in the levee. The full height of an additional 1.2–1.6 m on top of this would all be above mean sea level and certainly require the added depth of the storm surge and thus could only have been laid during the passage of such a wave.

If the cross beds of B8 represent the passing of a single wave, sedimentation occurred in a remarkably short time. Since a similar bedform was not produced by each cycle of waves, something unique occurred there. One explanation would be the failure of the levee's steel sheeting and broadening of the breach, providing the space for increased volume of flow in the neighborhood with the resulting depth increase and space for canal scour in the breach and the remarkable resulting quantity of clay in B8.

Figure 8 shows the angle of the cross beds of B8 decreasing upward as they approach the topmost laminae of the migrating dune from the left. As the splay built, depth limited further growth, as flow separation could no longer take place. Figure 12 shows the transition from high-velocity flat beds to dunes is "gradual." McKee et al. (1967, p. 836, brackets added) considered "low-angle foreset bedding [5°–10°]…along the outer margins of the sand sheet" to be the first sign of decreasing velocity. Decreasing depth pushed the flow down into this "gradual" transition zone.

The abrupt boundary at the top of B8 suggests a definite break or change in sedimentation. It is not a reactivation surface, which many books illustrate as a termination of cross bedding for a time, followed by its resumption (Nichols, 1999; McLane, 1995). Instead, it is a flat gap, a small-scale version of those examined by Roth (2009), which are both large and extensive in the sedimentary sequences of the western United States. He notes little or no erosion or weathering at these gaps, despite there being reservoirs for vast lengths of time for secular geology.

A flat gap in the middle of flat beds in the Katrina splay was attributed earlier to a change in depth in a continuous, unidirectional current. No velocity change was needed. Therefore, while the flat gap does represent a real gap in time, it is a very short gap measured in milliseconds to seconds, after which sedimentation resumed. Thus the boundary at the top of B8 likely did not reflect changing velocity, which would have produced different bedforms. Rather, it probably indicates a depth change, possibly at the end of a storm surge wave—in this case, the first/primary wave in a continuing wave train. The following wave in the train would have been smaller and less powerful (Figure 13).

Nichols (1999, p. 42) echoed a largely shared opinion: "The bed of sand which is formed from a decelerating flow will show a reduction in grain size.… Flows which gradually increase in strength through time … produce reverse grading." In other words, velocity changes are shown by grain size. However, McKee et al. (1967, p. 850, emphasis and brackets added) concluded that "stages in development of flood deposits may be recorded at any particular place by changes in the structure [bedforms] of sand. In contrast, the texture [diameter] of sand, although it may record rapid flow with relatively coarse grains and a decrease in velocity with finer grains *can be deceptive*." He repeatedly showed examples where coarse or fine sand in a rapidly accreting sequence was not a function of flow velocity but was more a function of sediment source. This is intuitive, though rarely considered; if only fine sand is available in a current, then nothing coarser will be deposited.

The only significant exceptions to this principle are sand surfaces of a deflation nature, winnowed of their finer fraction, or stable surfaces exposed to currents insufficient to move the coarse fraction, such as at the bottom of San Francisco Bay (Rubin and McCulloch, 1980) or eolian locations. However, none of these represent a rapidly accreting surface in a continuous, unidirectional current.

McKee et al. (1967, p. 850, emphasis added) recognized the intrinsic uniqueness of high-energy deposition:

> Strata of sand both in stream channels and on bordering flood plains, when deposited by a violent flood, contain dominantly horizontal layering characteristic of upper stream regimes. Much of the layering is in the form of fine laminae similar to the *type commonly ascribed to intermittent accumulation in quiet water over a long period of time*.

The Katrina splay deposits reinforce his observations and suggest that careless field interpretation of this type requires re-examination.

Layer C, with its two sublayers, is the deposit of two waves under conditions that limited the height. Formed of low-angle foresets, the slightly sloped laminae suggest this, as do the topmost ripples (Figure 9). Figure 14 illustrates the variety of possible bedform successions within the observed size range of splay sediments. Two different sequences are shown for fine sand. For the fraction > about 0.16 mm, the sand follows the sequence in Figure 12, flat beds to cross beds to ripples. Figure 12 was developed based on conditions beneath the double line at 0.25 mm in Figure 14. For the fraction < 0.16 mm, decreasing flow creates ripples atop flat beds.

The ripples at the top of Layer C at Point X (Figure 9) were possibly produced by decreasing velocity. While the transition from flat beds to ripples is appropriate for fine sand, close examination of Figure 9 suggests otherwise. The tops of the foresets with their low-angle cross-lamination extend directly up into the body of the ripples. Therefore, these are not ripples produced by decreasing flow but by wave ripples of the vortex variety (Nichols, 1999). These ripples are produced by high, sustained winds over the water surface, consistent with hurricane winds continuing after deposition. The sinuosity of the ripple crest, bending in front of the wall, is consistent with the wall's deflection of these winds.

What kind of ripples would be expected from decreasing velocity? McKee et al. (1967, p. 832) documented several locations at abrupt boundaries of deposition near preexisting banks, or "where receding water poured back into the main or subsidiary channels or where it swirled around the bases of large trees." There, flat beds shifted to low- to moderate-angle foreset bedding with *climbing ripple laminae* and convoluted structures. Nelson and Leclair (2006, p. 3) stated: “Spectacular cases of climbing dunes were seen on obstacles such as cars.” These are probably similar to bedforms McKee et al. (1967) observed around trees and other obstructions, caused by velocity drops at these locations.

The low-angle foresets of Layer C suggest a velocity decrease during deposition. McKee et al. (1967) thought that a change from flat beds to low-angle foresets was the first indication of diminishing flow velocity. If W (total height 1.8 m) is 20 cm higher than X (total height 1.6 m), then at W the top of C1 would be only 30 cm below the normal mean canal surface level, giving a depth to height ratio of 10:1 for deposition of the 3 cm sublayer. At the top of C2, the same depth would be 27 cm, giving a ratio of 9:1. These numbers, while reflecting our uncertainty of the exact conditions at the time, provide ratios near the 6:1 to 8:1 range of Allen (1976).

Calculations in Table III may be underestimates, as the Froude numbers for the Manning velocities are somewhat under the 0.844 limit proposed by Kennedy (1963). That the conditions remained near this point is consistent with the findings of Grant (1997, p. 356, brackets added) who found that: “interaction between the water surface and bedforms … maintain competent flows in mobile channels to Fr = 1 [at or just below critical flow].” This condition is favored because it moves the maximum amount of water while “dissipating current energy.” The areas swept clear of sediment suggests that conditions were near critical flow at all times. Table II Froude numbers are commensurate with those McKee et al. (1967) estimated at the Bijou Creek flood, which had a mean flow rate of 16.4 fps (5.0 m/s), a flow of up to 21.83 fps (6.65 m/s) in the main channel, and 11.8 fps (3.6 m/s) and a flow depth of 8–9 ft (2.5–2.75 m) with F_e = 0.74 in another location.

If these “planar strata” formed during high flow, but without distinct parting lenses at the cm scale or continuous distinct lamination expected from flume experiments with lower concentrations, then how did they form differently under hyperconcentrated flow conditions? Julien et al (1994, p. 8) explain how segregation of heterogeneous sediments takes place.

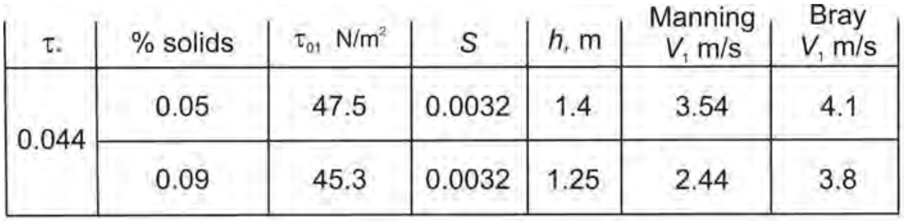
> Only the lateral motion of the mixture in any direction is necessary to induce segregation. During the lateral motion of the sand mixture … the fine particles fall through the interstices between the coarse particles and reach the bottom of the moving layer, while the coarse particles start rolling on top of the fine particles … After a certain time, the fine particles stabilize at the bottom of the moving layer while coarse particles remain mobile on top.

In a flume, dispersive shear stress caused by interaction between the solid particles is avoided by using low solids (Julien et al., 1994). This produces distinct continuous laminations but produces the slow growth progression of the bedform down the flume, requiring 20–30 minutes to build a thin layer of cross beds a few cm thick the length of the flume (Julien et al., 1994). This is consistent with their observation that “lamination becomes clearer as the rolling distance increases” (Julien et al., 1994, p. 9), with the clearest lamination being observed when the larger particles are allowed to form few-cm-thick cross beds.

But we need to understand how sedimentation varies with hyperconcentrated flows, when the dispersive shear stress is high and causes interactions between the solid particles, and the rolling distance for the larger particles is not great enough to allow clear lamination to form. Demonstrations in non-flume experiments with dry sediment mixtures of two different sizes or densities were shown by pouring or agitating in air (Julien et al., 1994). Many mixtures showed distinct separation based on size or density differences and rolling distance. A spectacular illustration was performed by Berthault, who put a wet heterogeneous mixture of sediments into a funnel, swirled it, and drained the water out the bottom (Berthault, 1988, p. 2). He produced a stack of laminae clear up the sedimentary column (Figure 15).

I believe that when a hyperconcentration is composed of a heterogeneous mixture of sedimentary materials, turbulence vectors do not interact equally with coarse and fine grains within the total depth of flow. Coarse grains will move more than fines by both Bernoulli forces and turbulence (McLane, 1995). Sorting of the heterogeneous mixture may begin wherever turbulence vectors are most dampened, but at concentration where solid particle interactions exceed dispersive shear stress, particle interactions will initiate incipient segregation through all levels of the flow.

As in producing the sets of laminae we recognized when reviewing the



τ_*	% solids	τ_{01} N/m²	S	h, m	Manning V_1 m/s	Bray V_1 m/s
0.044	0.05	47.5	0.0032	1.4	3.54	4.1
	0.09	45.3	0.0032	1.25	2.44	3.8

Table III. Calculated results based on maximum clast size (d_b = 0.07 m) in predominantly clay layers and differences in percent solids. Depth (*h*) and velocity (*V*) represent maximum conditions during storm surges.

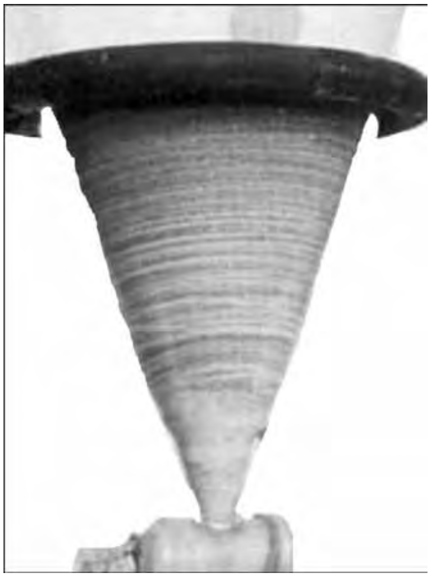


Figure 15. Hyperconcentrated laminar bedforms produced by swirling a wet heterogeneous sediment mixture and drawing the liquid out the bottom. Note large number of "laminar strata" produced atop each other in an instant of time. From Berthault (1988, figure 1).

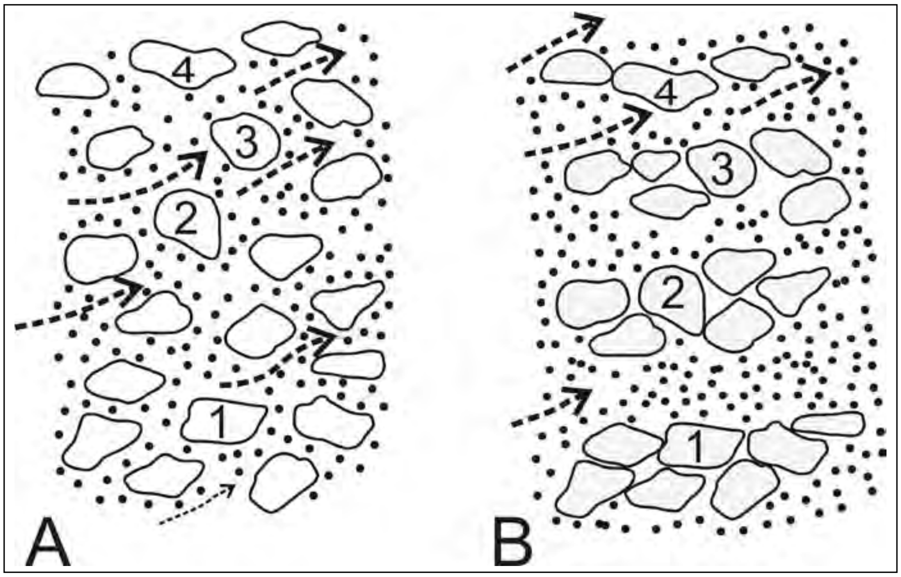


Figure 16. Segregation of particles under hyperconcentrated conditions begins when turbulence brings particles into contact. Larger particles will start to cohere more rapidly than smaller particles. When cohesive forces exceed viscous and shear forces, the larger particles aggregate, deflecting turbulence and moving closer together until they form distinct layers around multiple growth nuclei in multiple layers throughout the water column, not just on the bottom as under normal conditions. An incipient pavement forms, restricting smaller particles, which begin to collect on the pavement's upper surface. Because sedimentation is rapid, some fines remain as matrix, but most form layers between the coarser laminae. Since each layer is self-organizing around its own growth nuclei, the chances for a cm-scale lamination to grow continuously in all directions are limited due to the available sediments.

observations of McKee et al. (1967) of Bijou Creek, the production of stacks of laminae in a set needs an explanation. If a hyperconcentration of particles produces a high frequency of interactions between the particles, we can expect incipient segregation to begin in multiple stacked levels. This will result in distinct multiple moving layers—each with its own population of rolling and falling particles. Once segregation begins, the aggregate of large particles will form a pavement that traps small particles and blocks smaller turbulence vectors. Thus it begins to generate its own boundary layer. This, in turn, creates a series of cohesive and viscous sublayers and separate turbulence vectors maintaining layer integrity and prolonging roll time. This allows fines to migrate downward; thus each aggregate is able to grow with coarser particles on its undersurface (Figure 16).

Julien et al. (1994, p 8) noted that it is a continuous interaction of "fine particles … [which] reach the bottom of the moving layer … while coarse particles remain mobile on top," but as a result of the concentration, it is happening simultaneously on many levels in the flow with only abbreviated rolling distance for each particle.

This is significant because it means that sets of discontinuous laminae can form together. Interaction between cohesive and viscous forces limits the thickness of laminae that can form within given conditions of solids concentrations and depths. The 6:1 to 8:1 ratio of flow depth to laminae thickness used above should be applied to an entire set of laminae produced under hyperconcentrated conditions. Cross bedding produced under these conditions may actually deposit the set of laminae in sets that will break off and slip down the stoss slope. That would account for relatively regular interspersing of clay drapes in cross bedding (Figures 8 and 11) and provide the presence of clay drapes as an indicator of hyperconcentrated conditions.

In the Katrina splay deposits, the low-angle foresets of Layer C represent the first indication of a decrease in velocity, but because multiple boundary layers existed simultaneously at discrete levels within the current, flow separation over the total depth did not occur. Formation of new laminae took place preferentially at the lead surface of the hyperconcentrated flow, and the reduced velocity allowed the laminae set there to settle faster than it formed, producing low-angle foresets. Convoluted bedding formed when the flow decreased below the threshold of forming linear lamination. Thus, low-angle foresets and convoluted bedding are a progression produced in a hyperconcentrated flow under conditions of decreasing velocity without formation of a dune with a lee slope.

What will form is a set of mm-scale laminae that are irregularly discontinuous both parallel and perpendicular to flow. Parting laminae are present at the mm scale but are discontinuous because of the constant alternation of coarse and fine layers, and the interruption of one lamina by another forming simultaneously at another loci. Individual aggregates of large particles and clusters of such aggregates together form a single boundary layer with an irregular flat form and perimeter, so a cross section through the deposit shows randomly arranged, stacked, flat laminae less extensive on the cm scale. These characteristics of hyperconcentrated laminar bedding would place it as a subcategory of hyperconcentrated flood-flow deposits as defined by Smith (1986). As a group, hyperconcentrated flood-flow deposits, and hyperconcentrated laminae are distinct in other examples in the rock record, indicating high concentrations of solids, high velocity, and relatively shallow flow depths. Clearly, this diagnostic tool would be significant in diluvial investigations.

In summary, high-flow regime flat beds are produced over a range of solids concentrations, but the actual form varies with concentration. At ~ 5% solids, hyperconcentrated laminar bedforms are produced in sets without clear parting layers at the mm scale. This unique appearance is diagnostic of hyperconcentrated conditions. McKee et al. (1967, p. 850) observed that they are "similar to the type commonly ascribed to intermittent accumulation in quiet water over a long period of time." Given the radically different depositional conditions, it is imperative that they be distinguished from other flat beds in the field.

Mudstones and shales were once thought to represent quiescent sedimentation. Schieber et al. (2007) have demonstrated otherwise. Their work is supported by the Katrina splay deposits: even at high velocity, clay ovoids and floccules will form by cohesion and be deposited as distinct cm-scale laminae in regular sets of flat beds. Concentration of clay leads to the formation of floccule streamers and in turn to large, continuous sheets of clay. It seems logical that if floccule streamers are forming, and increasing clay concentration increases streamer size, then increased distance will result in larger sheets, perhaps equivalent to the "rolling distance" for the separation of bed load.

Hyperconcentrated laminar bedforms are laid down in sets whose characteristics are determined by the depth of the energy surge added to a continuous unidirectional current. Greater depth deposits thicker sets. Surges vary both depth and flow energy, and changes can occur as rapidly as the passage of individual waves. Even if depth remains the same, a change in energy will be seen as a small flat gap in the continuously depositing column.

Successive sets will only show interruptions for incidental events overlaid on the unidirectional steady flow and the wave surges. These include variations in sediment composition, flow eddies, obstructions, or, as was seen in New Orleans, the effect of wind on the water surface. Incidental time markers, such as pebble impressions or repeated patterns of deposition are the only obvious indicators of set separation, and they may be used to fix a mean set size indicating flow depth and the rate of deposition per wave.

Conclusions

A canal breach caused by Hurricane Katrina resulted in deposition of 1.8 m (5.9 ft) of sediment in a New Orleans neighborhood. This splay deposit shows that the variety and sequence of both sediments and bedforms are equally important in discerning the depositional conditions. Although the splay covers less than 0.003 km^2 (0.0011 mi^2), its hydrodynamic information can be extrapolated to much larger deposits in the rock record.

Despite features commonly attributed to low, slow flow, the splay deposits were clearly formed by sedimentation in a continuous unidirectional current, overlaid by storm surge waves. Published accounts provide a maximum time of 46 minutes for sedimentation, and a more likely minimum of 2–3 minutes is established, based on the wavelength of the storm surges. Sediment source played an important role. Significant changes in velocity or fluctuations of an active/passive cycle of sedimentation cannot be supported as occurring without diagnostic changes in bedform. The occurrence of clay layers or minor erosional surfaces in an otherwise continuous, rapidly accreting bedform can no longer be considered to reflect such a change in velocity. Clay sheets occur as clay drapes in cross beds or sheets between laminae, both expected from experiments on heterolithic stratification, and both deposited in the high-velocity current, not times of low current flow. Therefore, without significant additional evidence from the sediments or the bedforms to the contrary, the occurrence of clay sheets or layers in the sequence should no longer demand a chronostratigraphic horizon.

The splay deposits also demonstrated that flat beds can be succeeded by cross beds and then revert to flat beds within a continuous, single, unidirectional current, caused by depth variations under constant flow. They also show that a sequence of wave-deposited bedforms, which could easily be interpreted in the rock record as long periods of time, can be the product of continuously depositing waves, in sequence. Under conditions of continuous deposition, the waning stage of the wave will leave some evidence in the bedforms. Under hyperconcentrated conditions, that evidence may be as small as a low-angle increase in the laminae.

Grain size strongly influences bedforms. Different grain sizes will produce different sequences. A bedform or series of bedforms will not necessarily display graded upwards lamination if the smaller grains are not available or if the roll time is not adequate for such a clear separate bedform to occur. Hyperconcentration of solid particles is a common situation under which clear parting layers will not be produced by increase rolling time.

As long as an adequate source of both current and sediment is maintained, these small splay deposits show that a sedimentary pile of great thickness can accumulate rapidly in shallow water under hyperconcentrated conditions. Furthermore, it suggests that when hyperconcentrated laminar bedforms are present, the measured rate of deposition will be only a few minutes per meter of sediment. This rate is elevated relative to current thought and will vary with flow, obstructions, depth, and sediment source. These can be deciphered only by examining the range of bedforms in a given formation. Furthermore, rates may rise even more as we use hydrodynamics to properly discern these conditions—using them to broaden our understanding of sedimentation during the Genesis Flood.

Finally, this evaluation demonstrates the superiority of a hydrodynamic analysis to interpretation in terms of facies models. No facies model was applicable to the splay deposits, and that should raise questions about other sediments in the rock record. This is another argument for a different approach to the rock record: abandoning the facies model system and working out the mechanics of deposition instead. Likewise, these deposits show that carefully arranged bedforms are not produced in a haphazard manner. The physics of sediment transport and deposition in moving water are well known and provide hard guidelines for the required physical conditions associated with particular bedforms. Although much about diluvial processes is not the same as those occurring today, the physics of deposition are, and thus the Katrina splay deposits provide a real modern analog for ancient deposition. Speculative environmental scenarios that exceed the available data are a poor substitute for rigorous scientific analysis of the sediments found in the rock record, blinding geologists to the need for more accurate, but more difficult quantitative sedimentological analyses.

References

Allen, J.R.L. 1976. Bedforms and unsteady processes: some concepts of classification and response illustrated by common one-way types. *Earth Surface Processes* 1:361–374.

Barwis, J.H., and M.O. Hayes. 1985. Antidunes on modern and ancient washover fans. *Journal of Sedimentary Petrology* 55(6):907–916.

Berthault, G. 1988. Experiments on lamination of sediments. *Technical Journal* 3:25–29.

Berthault, G. 2002. Analysis of the main principles of stratigraphy on the basis of experimental data. *Lithology and Mineral Resources* 37(5):442–446.

Bridges, J.S. 2003. *Rivers and Floodplains*. Blackwell, Oxford, UK (cited in Nelson and Leclair, 2006).

Eustis Engineering Co., Inc. 1986. Geotechnical investigation, London Avenue Outfall Canal: New Orleans, OLB Project No. 2049–0269 1–2:264 (cited in Nelson and Leclair, 2006).

Froede, C.R. 1995. Dauphin Island, Alabama: Evidence for rapid erosion. *Creation Research Society Quarterly* 32:143–148.

Gomez, B., J.D. Phillips, F.J. Magilligan, and L.A. James. 1997. Floodplain sedimentation and sensitivity: Summer 1993 flood, Upper Mississippi River Valley. *Earth Surface Processes and Landforms* 22:923–936 (cited in Nichols, 1999).

Grant, G.E. 1997. Critical flow constrains flow hydraulics in mobile-bed streams: a new hypothesis. *Water Resources Research* 33(2):349–358.

Julien, P. 1998. *Erosion and Sedimentation*. Cambridge University Press, New York, NY.

Julien, P.Y., Y. Lan, and G. Berthault. 1994. Experiments on stratification of heterogeneous sand mixtures. *TJ* 8(1):37–50.

Kennedy, J.F. 1963. The mechanics of dunes and antidunes in erodible-bed channels. *Journal of Fluid Mechanics* 16:521–544.

Knabb, R.D., and J.R. Rhome. 2005. Tropical cyclone report: Hurricane Katrina. National Hurricane Center. 20 December 2005 (cited in Timeline, 2006).

Lalomov, A.V. 2007. Reconstruction of paleohydrodynamic conditions during the formation of Upper Jurassic conglomerates of the Crimean Peninsula. *Lithology and Mineral Resources* 42(3):268–280.

Lowe, D.R. 1982. Sediment gravity flows II. Depositional models with special reference to the deposits of high-density turbidity currents. *Journal of Sedimentary Petrology* 52:279–297 (as cited in Shanmugan, 1996).

Marshall, B. 2005. 17th Street Canal levee was doomed. *Times Picayune*, 30 November 2005.

McKee, E.D., E.J. Crosby, and H.L. Berryhill Jr. 1967. Flood deposits, Bijou Creek, Colorado, 1965. *Journal of Sedimentary Petrology* 37:829–851.

McQuaid, J. 2005a. Anatomy of a disaster. *Newhouse News Service*. 8 September 2005 (cited in Timeline, 2006).

McQuaid, J. 2005b. Swamp peat was poor anchor, engineer says. *Times Picayune*. 15 October 2005.

McLane, M. 1995. *Sedimentology*. Oxford University Press, New York, NY.

Nelson, S.A., and S.F. Leclair, 2006. Katrina's unique splay deposits in a New Orleans neighborhood. *Geological Society of America Today* 16(9):4–10.

Nichols, G. 1999. *Sedimentology and Stratigraphy*. Blackwell Publishing, Boston, MA.

Place of Dead Roads, The. 2005. NOAA/NWS knew of levee breach morning of Monday 29th. http://theplaceofdeadroads.blogspot.com/2005/09/Noaanww-knew-of-levee-breach-morning.html.

Polyakov, A.S. 2002. Properties of granular media and transportation mechanism of subaqueous debris flow. *Lithology Mineral Research* (English translation) 37(1):25–31 (cited in Lalomov, 2007).

Reed, J.K., and C.R. Froede Jr. 2009. Interpreting the Hydrodynamic Flow Regime of the Genesis Flood through Provenance Studies of Clastic Sediments. *Creation Research Society Quarterly* 46:109–117.

Roth, A.A. 2009. "Flat gaps" in sedimentary rock layers challenge long geologic ages. *Journal of Creation* 23(2):76–81.

Rubin, D.M, and D.S. McCulloch. 1980. Single and superposed bedforms: a synthesis of San Francisco Bay and flume observations. *Sedimentary Geology* 26:207–231.

Schieber, J., J. Southard, and K. Thaisen. 2007. Accretion of mudstone beds from migrating floccule ripples. *Science* 318:1760–1763.

Schumm, S.A. and H.R. Khan. 1972. Experimental study of channel patterns. *Geological Society of America Bulletin* 83:1755–1770.

Seed, R.B. 2005. Hurricane Katrina: performance of the flood control system. Testimony before the Committee on Homeland Security and Government Affairs, US Senate. University of California, Berkeley. 2 November 2005.

Shanmugan, G. 1996. High-density turbidity currents: are they sandy debris flows? *Journal of Sedimentary Petrology* 66(1):2–10.

Smith G. 1986. Coarse-grained nonmarine volcaniclastic sediment: terminology and depositional process. *Geological Society of America Bulletin* 90:1–10.

Southard, J.B. 1971. Representation of bed configurations in depth-velocity-size diagrams. *Journal of Sedimentary Petrology* 41:903–915 (cited in McLane, 1995).

Thomas, R.G., D.G. Smith, J.M. Wood, J. Visser, E.A. Calverly-Range, and E.H. Koster. 1987. Inclined heterolithic stratification – terminology, description, interpretation, and significance. *Sedimentary Geology* 53:123–179 (cited in Nichols, 1999).

Timeline of Hurricane Katrina. 2006. Wikipedia. http://en.wikipedia.org/wiki/Timeline_of_Hurricane_Katrina. downloaded 10/8/2009.

Vink, T. 1926. De Lekstreek, een aardrijkskundige verkenning van een be woond deltagebied. PhD diss., University of Utrecht, Utrecht, The Netherlands, (cited in Nelson and Leclair, 2006).

Walker, T. 2007. Katrina's splay deposits: a small example of the power of flowing water. *Journal of Creation* 21(3):8–11.

Battlegrounds of Natural History: Naturalism

John K. Reed, Emmett L. Williams*

Abstract

Scientific creation battles the worldview of naturalism at the level of scientific fact and theory, but crucial battlegrounds are also found in the foundational concepts that shape the method and direction of science. One of these is summarized by the term "naturalism." This debate is hindered by equivocal terminology, presuppositional inconsistency, and the use of secular premises by some Christians—typically from a desire to "triangulate" between biblical creation and atheism. Science is the child of Christianity, but enduring secular distortions have succeeded in convincing most people that naturalism is one and the same with science, and that it is legitimate to extrapolate from the scientific method to atheism. Those core distortions are protected by ancillary arguments; chief among them, a strategy of diverting Christians with arguments regarding the reality or possibility of miracles and with accusations of "god-of-the-gaps" reasoning. In response: (1) metaphysical naturalism is invalid because it fails logical truth tests, (2) methodological naturalism is an unnecessary accretion to basic attributes of science historically derived from Christian theology, and (3) the ancillary issues are defused by sound reasoning. The key to addressing the concept of naturalism in its totality is the recovery and application of the traditional Christian doctrine describing God's providential relationship with creation.

Introduction

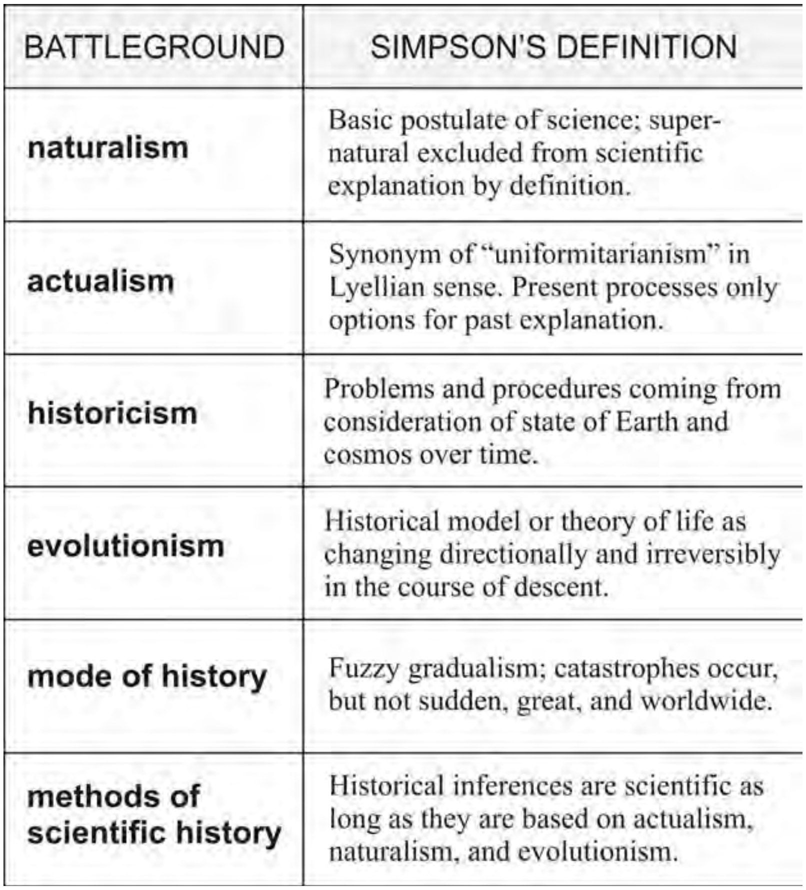
Many Christians are confused by attacks on their faith from science—in particular by the claim that the very method of science is an antitheistic proof. These attacks are subsumed under the name "naturalism," even though that term is used equivocally. This paper will unravel its distinct meanings and then evaluate its major arguments against orthodox Christianity. We will then show that sound theology alone provides a clear, consistent basis for science. This is the first of a series of articles that will address foundational arguments about natural history's assumptions and methods.

This analysis is important because natural history was an early and effective avenue of attack on the church and it remains a redoubt of secularism. It is upheld by at least six fundamental errors

---

* John K. Reed PhD, Evans, Georgia, reed4004@gmail.com
Emmett L. Williams, PhD, Alpharetta, GA
Accepted for publication March 22, 2011

Figure 1. George Gaylord Simpson (1902–1984) was one of the foremost evolutionists of the twentieth century.



BATTLEGROUND	SIMPSON'S DEFINITION
naturalism	Basic postulate of science; supernatural excluded from scientific explanation by definition.
actualism	Synonym of "uniformitarianism" in Lyellian sense. Present processes only options for past explanation.
historicism	Problems and procedures coming from consideration of state of Earth and cosmos over time.
evolutionism	Historical model or theory of life as changing directionally and irreversibly in the course of descent.
mode of history	Fuzzy gradualism; catastrophes occur, but not sudden, great, and worldwide.
methods of scientific history	Historical inferences are scientific as long as they are based on actualism, naturalism, and evolutionism.

Figure 2. Six foundations of modern natural history as noted by Simpson (1970).

that have been widely accepted as true, and that set it at odds with Christianity (Figure 2). Though enumerated by evolutionist George Gaylord Simpson (Figure 1), they are axioms requiring clarification for anyone seeking truth in nature and in history.

This series will examine each of these six errors. All are falsified by Biblical truth, properly applied. Because these topics sweep across metaphysics, epistemology, science, history, theology, and natural history, our treatment is cursory but hopefully helpful.

The initial topic, naturalism, presents formidable difficulties. First, it is probably the most culturally persistent of the six. Second, both the term and its underlying concepts are used equivocally. Third, the rules of debate are defined by secular premises. Fourth, it is an emotional argument, as illustrated by the spate of recent books pitting atheists against Christians (e.g., Dawkins, 2006a; Hitchens, 2007; Harris 2004, 2006; vs. Day, 2008; D'Souza, 2008; Keller, 2008). Fifth, distinctions between the traditional scientific method and "methodological naturalism" have been blurred. Sixth, Christians have been diverted by red herrings—miracles and accusations of "god-of-the-gaps" reasoning. Finally, Christians hostile to a creationist perspective unfortunately reinforce secular errors by seeking an impossible compromise between two irreconcilable contraries.

Untangling these knots requires cutting through historical misinformation about the origin of science—it was not an exercise in gaining freedom from superstition but the well-organized hijacking of the Christian enterprise by Enlightenment "freethinkers." Even now, centuries later, many Christians do not understand the extent of the deception in popular secular fables and often uncritically accept secular premises. These, in turn, hide the equivocation that takes the form of a sliding scale between naturalism as a method and naturalism as a worldview—similar to the strategy confusing "uniformity" and "uniformitarianism" (Reed, 1998a). Secular thinkers advance the worldview until challenged, and then piously claim to be merely adhering to the scientific method.

This is more than a defensive tactic; it provides the basis for arguing an inevitable link between science and atheism. Christians have fallen for this over and over because we fail to see the unstated premise of positivism, the idea that science rules the realm of truth. Whenever we grant science the power to dictate truth outside its legitimate boundaries, "methodological" naturalism expands unimpeded into a full-fledged worldview.

Given the persistence of this secular sliding scale, it would be foolish to see it as accidental—it is a deliberate weapon against Christianity (Adler, 1992). This is not new; Stark (2003) noted the same ploy was used by many Enlightenment savants. As a result, secular propagandists have turned science to the "dark side" for many years, despite its Christian roots (Glover; 1984; Hooykaas, 1972, 1999), and have then used "dark-side" science to bolster their worldview.

Ironically, it is the hubris of new atheists that has recently alerted Christians who are not creationists. They have finally begun to grasp what Henry Morris (1974) noted long ago, and have responded forcefully, if incompletely, to the claims of the new atheists. Even so, they often do not acknowledge that creationists have led the way, providing the most consistent arguments—a reasonable state of affairs since, after all, science ultimately rests on the Biblical doctrine of creation.

In response, we will divide and conquer. First, we will refute the worldview of naturalism. Thanks to its inherent contradictions, this is not a hard task. The more difficult challenges are to separate methodological naturalism from the method of science and stop the misguided pursuit of the red herrings of miracles and "god-of-the-gaps." All of these efforts require precise thinking. For example, many confuse the worldview of naturalism with metaphysical materialism (Figure 3). It is a subtle distinction, but worldviews are more than metaphysics, and we cannot afford to ignore secular epistemology (positivism) or the secular philosophy of history (actualism).

This paper will first describe and evaluate "metaphysical naturalism" and then do the same to "methodological naturalism." After then dismissing arguments against miracles and "god-of-the-gaps" accusations, we will show how the recovery of the biblical doctrine of providence offers a positive basis for reintegrating science into its parent worldview of Christianity.

Metaphysical Naturalism

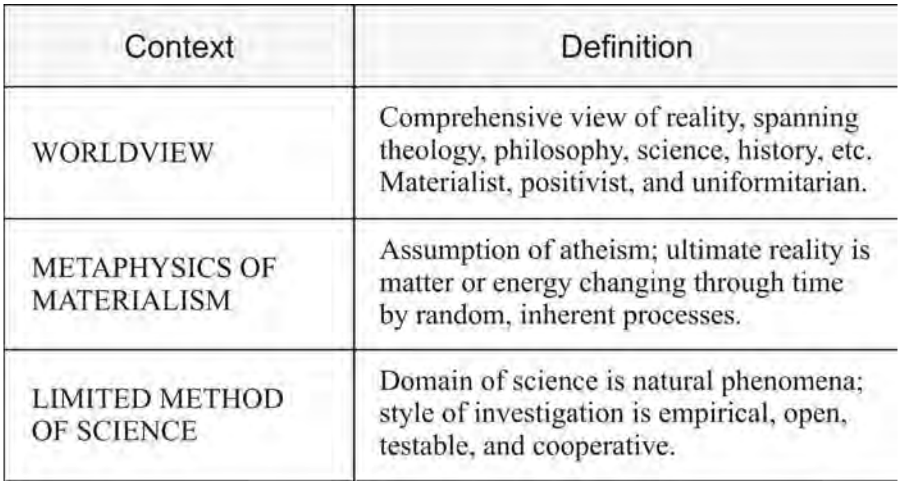
Two Views of the Road to Metaphysical Naturalism

Metaphysical naturalism is at least as old as Greek atomism, and was routinely rejected from Plato to the Enlightenment. However, it resurfaced as a distinctive post-Christian secularism during the Enlightenment, when antitheistic intellectuals turned to science, and then used it to mask their worldview (Stark, 2003). We explore two perspectives on this transformation. The first focuses on method (Figure 4) and the second on theology (Figure 5).

Early scientists developed a self-consciously Christian method to investigate phenomena while avoiding theological and philosophical tangles. They understood that science was limited and contingent, with axioms upheld by Scripture (Glover, 1984; Hooykaas, 1972, 1999; Klevberg, 1999; Lisle, 2009; Reed, 2001; Reed et al., 2004). Their genius was in drawing distinctions between practical and theoretical—without separating the two—that relegated axioms to the background (Figure 4A), allowing unimpeded scientific inquiry (Glover, 1984).

While science could be distinct in practice, it remains inextricably linked to theology because theology justifies its presuppositions. For example, theologians teach that God was free to create according to His desires, unconstrained by external rational principles. This drove an empirical method; if we want to understand nature, we rely on inductive investigation, not deductive philosophy. This approach marks modern science (Glover, 1984). Many examples could be cited, but the principle is the same—"religion and science not only were compatible; they were *inseparable*" (Stark, 2003, p. 3, emphasis added).

Figure 4B illustrates the first step toward error. Carelessly assuming what had been explicit, thinkers began to see the practice and theory of science as separate. Epistemic theory was messy; practice was stunningly successful. How could one argue with steam engines? But downplaying the theoretical opened the door for it to be dismissed by the proto-positivism of the eighteenth century (Figure 4C). Science came to be seen as an autonomous arbiter of truth, mostly because it seemed so productive compared to philosophy and theology. Its results were clearcut and precise. The Bible went from being the founda-



Context	Definition
WORLDVIEW	Comprehensive view of reality, spanning theology, philosophy, science, history, etc. Materialist, positivist, and uniformitarian.
METAPHYSICS OF MATERIALISM	Assumption of atheism; ultimate reality is matter or energy changing through time by random, inherent processes.
LIMITED METHOD OF SCIENCE	Domain of science is natural phenomena; style of investigation is empirical, open, testable, and cooperative.

Figure 3. Distinct definitions of "naturalism" showing basis for modern errors of equivocation.

tion of science to being the focus of its critical assessment. Of course the logical conclusion (Figure 4D) was that both theology and God were unnecessary. Humean skepticism and Kantian rationalism permanently detached God from the physical world. Because the Christian worldview still permeated Europe, the axioms of science were assumed to be true by "common knowledge" rather than logical demonstration.

Another way to examine this progression from Christian to secular science is by the change in how people saw nature's relationship to God (Figure 5). Science was born in the medieval university system (Hooykaas, 1999; Stark, 2003), and its theoretical underpinnings grew out of the "fruitful failure" of scholasticism (Glover, 1984). Everyone knew that God ruled the world by His providence, whether He acted directly or used indirect means. As science began to develop, its practitioners found a helpful shortcut—the regularities of providence became "laws of nature." It was easier to attribute the acceleration of falling objects to the constant force of gravity than to the intricate workings of divine providence.

Classical science sought to unveil universal principles governing motion, chemical interactions, and biological classification. Science discovered principles, but the assumed regularities were a function of God's making and ruling nature. However, it is easier to ignore theological points.

Science's success was its undoing. Newton's synthesis convinced people that science was autonomously powerful, bringing a practical clarity that contrasted sharply with the tangled debates of theologians and philosophers. Descartes' method of doubting everything reinforced the dismissal of authority, and Locke's *tabula rasa* encouraged an unrealistic view of man's objectivity. Soon, natural law was decoupled from God's rule and care, becoming progressively more invariant and absolute.

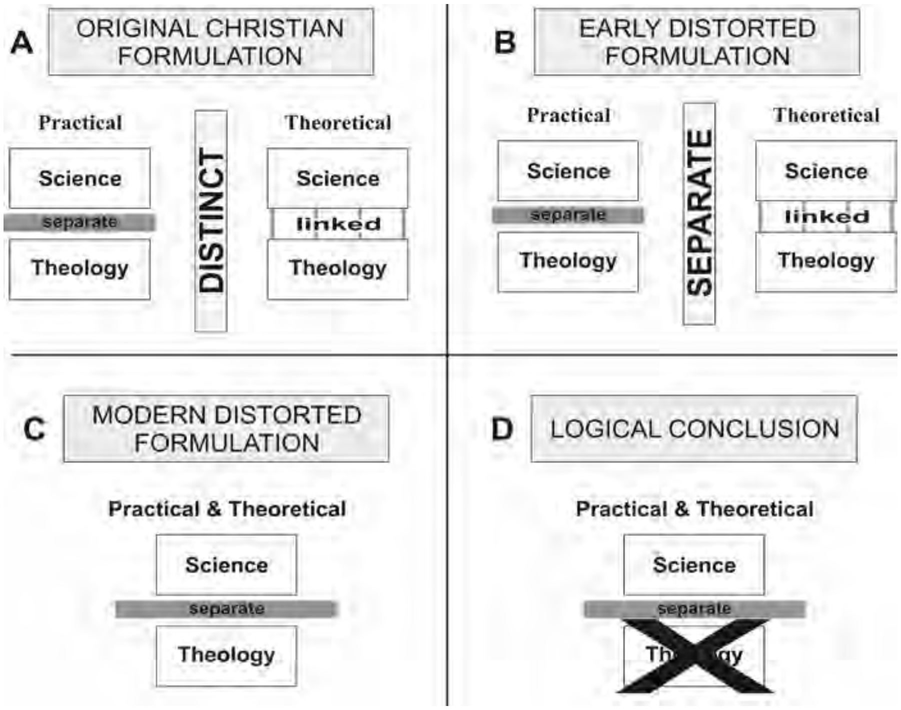
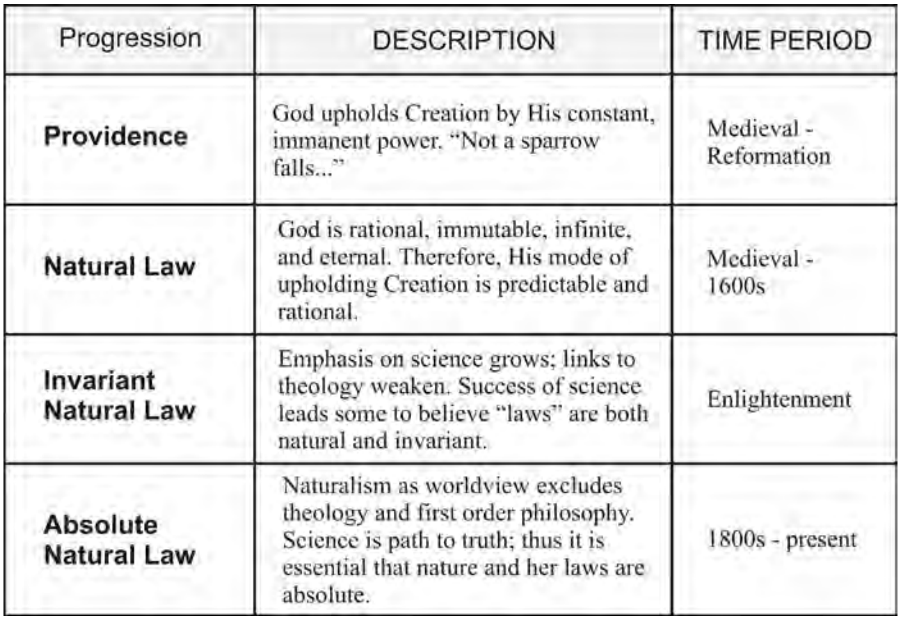


Figure 4. Progression to metaphysical naturalism. A. Christian thinkers distinguished the practical and theoretical relationship between theology and science to prevent metaphysical argument from intruding into practical investigations. B. The growing success of science and growing disunity in philosophy led to a separation between practical science and its theoretical foundations. C. Following Kant's critique, science was seen as autonomous, both in practice and theory. D. The logical conclusion of that position is that theology is meaningless in the pursuit of objective truth.



Progression	DESCRIPTION	TIME PERIOD
Providence	God upholds Creation by His constant, immanent power. "Not a sparrow falls..."	Medieval - Reformation
Natural Law	God is rational, immutable, infinite, and eternal. Therefore, His mode of upholding Creation is predictable and rational.	Medieval - 1600s
Invariant Natural Law	Emphasis on science grows; links to theology weaken. Success of science leads some to believe "laws" are both natural and invariant.	Enlightenment
Absolute Natural Law	Naturalism as worldview excludes theology and first order philosophy. Science is path to truth; thus it is essential that nature and her laws are absolute.	1800s - present

Figure 5. Progression from methodological to metaphysical naturalism from a theological perspective on God's relationship to nature.

In time, opponents of the church seized science and distorted it for their own ends. Theology no longer chugged along in the background; it was dismissed as irrelevant. Deism kept a figurehead creator, but once it imbued nature with self-perpetuating laws, the creator withdrew. Nature was no longer the domain of God's immanence, where everything was a "wonder" (Hooykaas, 1999) but simply a grand playground for man's scientific genius. In retrospect, it seems incredible that Christianity was so easily dismissed, but the historical reality remains.

> Why there should have been a fading at this time of just those aspects of the Christian intellectual tradition that were most relevant to the new science—and not only relevant to it but congenial to it—is an intricate historical problem to which no adequate answer can be given here. *The fact itself is beyond question* and of the greatest importance in the intellectual history of Western culture (Glover, 1984, p. 97, emphasis added).

Deism was the bridge to atheism. Modern atheism and its worldview of naturalism first co-opted science and then used science to co-opt culture. Nature and its "laws" were absolute; there was no need for the "God hypothesis." Enlightenment strength coincided with a weak church, and the result was our modern secular culture.

> This was the grand age of science, when it seemed to the leading scholars of the humanity that the sure road to understanding all things had finally been discovered in science and its Rosetta stone, the scientific method (Bauer, 1992, p. 34).

Scientists continued to use Christian axioms, but lost their theological basis and made sure everyone else did too by creating a mythology that pictured science as a secular force freeing mankind from religion.

Atheism was equally at home at the Bastille and at Oxford, and developed a link between science and politics (Buffon/Robespierre; Marx/Stalin; Nietzsche/Hitler) that illustrated its "will to power." Lip service soothed the church while secularism eviscerated Christianity. Those Christians who saw and opposed this trend were silenced or ignored, often by other Christians (Mortenson, 2004). Humanistic optimism peaked in the nineteenth century; philosophers like Hume, Kant, and Hegel joined scientists like Lyell and Darwin to "emancipate" mankind from God. Man was in the driver's seat, and the road ahead looked smooth.

But potholes of reality hit Europe in 1914 and just got larger over the rest of the century. The wonders of technology were offset by world wars, communist brutality, and the nuclear age. Then the philosophers jumped ship; the postmodern rejection of truth has brought us to the point where science seems anachronistic, and philosophers of science question whether there is even such a thing (Bauer, 1992). Utopia is out; apocalypse is in.

G. G. Simpson: A Milepost on the Road from Damascus

Secular arrogance still reigned in mid-twentieth-century America, ignoring rumblings from philosophers like Sartre and Camus. Scientists were treated like the pope—they could as oracles speak about everything from ethics to eternity. George Gaylord Simpson represented the spirit of that age, and thus it is worth examining his comments on the relationship of science and theology. Simpson (1970, p. 61) stated:

> Naturalism is a basic postulate of science as now almost always construed, a necessity of method and procedure in science regardless of what theological or philosophical stand may be taken on it.… If only on heuristic grounds, scientific explanation must not invoke the supernatural, non-natural, noumenal, or any other preternatural factor.

This quote readily captures the deceptive mind-set of secularism. He begins by invoking naturalism as simply a part of science, "a necessity of method and procedure," but he does not explain *why* it is necessary. Once on the slippery slope, he slides along, stating that scientific explanation must not invoke theology or metaphysics. Newton and Darwin might both have agreed with those words, but would have had quite different ideas about what they meant. Ironically, Simpson ignored the fact that claiming the independence of science from metaphysics is itself a *metaphysical* assertion.

Simpson is correct that the proper domain of science is natural phenomena. But since modern secular culture does not allow a reality outside of natural phenomena, the result is the overweening belief that science, not religion, is the doorway to truth. Theology and philosophy are adjuncts that serve subjective human needs. The whole "bait and switch" strategy of naturalism the method and naturalism the worldview is predicated on that autonomy. Simpson may sound eminently reasonable, but is actually quite dogmatic.

That is why the initial Christian response had to recognize the problem—the reality of naturalism as a competing worldview. Only then was it possible to change the rules of the debate by forcing atheists to define their terms and defend their presuppositions (Lisle, 2009; Reed, 2001). Allowing the mechanistic method of science to drive people to a mechanistic worldview by invoking an implicit positivism is *the fundamental error* of modern science.

Simpson (1970) underscored his view in his discussion of Hutton's deistic geotheory (cf. Reed, 2008; Reed, J.K. and P. Klevberg. 2011. The genre of geotheory: past and present. *CRSQ* 48(1):20–32), which insisted that physical phenomena have operated through time by innate natural processes.

> Given the system of the earth, which, however or whenever it came to be,

> had been cycling for uncountable aeons, Hutton was very definite that its operation excludes the preternatural. That aspect of what later came to be called uniformitarianism in a broad sense was particularly objectionable to theologians (Simpson, 1970, p. 48).

It still is. Sadly, even Simpson's faulty analysis was more careful than that of many of his peers. Less thoughtful atheists insist that God plays no role in science because there is no God. How do we know that there is no God? By science, of course! The circularity of this argument never seems to penetrate their hidebound bias. Science is their faith. How else are we to explain the ranting of Dawkins (2006b)?

> The enlightenment is under threat. So is reason. So is truth. So is science, especially in the schools of America. I am one of those scientists who feels that it is no longer enough just to get on and do science. We have to devote a significant proportion of our time and resources to defending it from deliberate attack from organized ignorance. We even have to go out on the attack ourselves, for the sake of reason and sanity.

It is Dawkins who has abandoned reason and sanity. Similar citations could be multiplied. Less vitriolic atheists may be more polite but still have the same goal, to crush Christianity. Gould's (1997) "NOMA Solution" is a prime example of smiling at your foe while slipping a stiletto into his vitals (cf. Reed, 1998b).

But Simpson's generation was the last hurrah of the great Enlightenment scam because its façade was ripped apart by modern creation science. The reason creationists evoke oceans of vitriol is because they have the temerity to use *science* against secularism. For two centuries, the shoe had been comfortably on the other foot. In the eyes of "high church atheism" (Day, 2008), creationists committed the most heinous sin. Scientists—supposedly advocates of naturalism—had become traitors, making *scientific* arguments for "religious superstition."

Atheists rage in response to an attack on their secular *faith*. Simpson wrote more dispassionately than Dawkins, perhaps because in 1970 no one imagined that creationists could actually breach the citadel of the neo-Darwinian synthesis. Dawkins and P. Z. Myers react quite differently today, having seen the ravages inflicted on their religion. Naturalism, as a worldview, is cornered and dangerous. Its defeat is a primary concern of all Christians.

How to Defeat "Metaphysical" Naturalism

Though it is heartening to see more Christians respond to the new atheism, it is disheartening that many of their arguments are incomplete, inconsistent, and misdirected. They are incomplete because they do not address many of the false premises of secularism, such as positivism. They are inconsistent because they do not link confidence in truth to the integrity of the Bible. They are misdirected because, with few exceptions, they keep looking for compromises to save science rather than trying to wrest it back to its legitimate home.

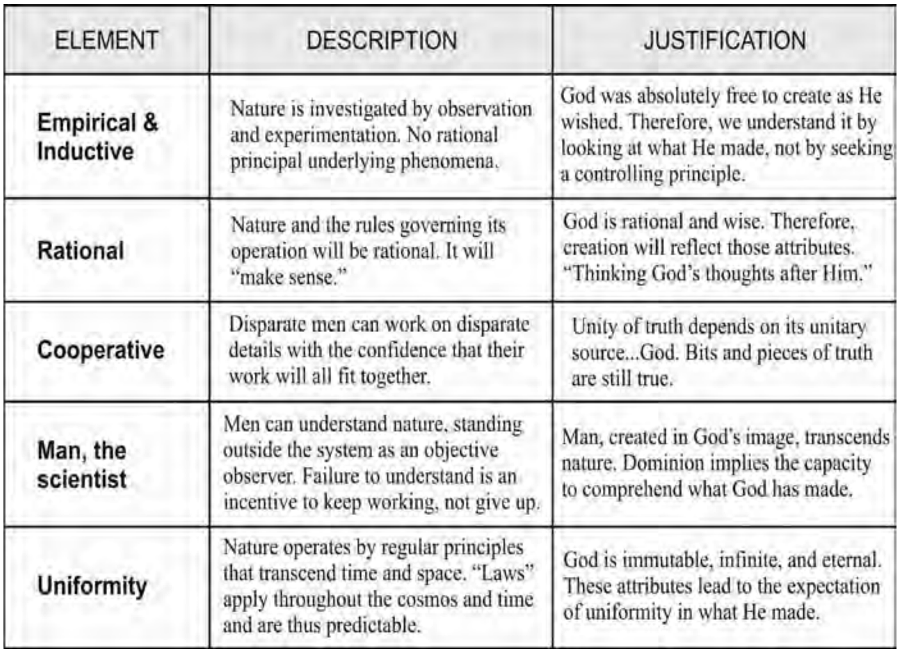
In spite of these shortcomings, there is a range of work by Christians objecting to naturalism: from the winsome logic of C. S. Lewis to the thoughtful theology of Francis Schaeffer, to the pointed philosophy of men like Gordon Clark and Alvin Plantinga, and, finally, to the apologetics of creation science and intelligent design. Without rehashing all of the arguments, suffice it to say that it has become obvious that when modern atheists confront informed Christians, they invariably lose the debate.

Unfortunately, most contemporary apologetics fall short. In order to defeat naturalism, its relationship to both physics and metaphysics must be clearly defined. For a long time, its advocates were able to use science to divert deeper inquiries. But as a worldview, it has a distinct metaphysic, epistemology, and even a philosophy of history. Most Christians attack peripheral manifestations in ethics, politics, religion, and the social sciences—in other words, the contemporary cultural consensus. But it is necessary to get to the heart of the matter with logical assaults on its most foundational axioms. When Enlightenment savants stole science from Christianity, they began juggling a live grenade because the presuppositions of science are Christian. For example, Glover (1984, pp. 84–85) noted:

> Nominalists and voluntarists already were aware of regularity and order in the world.… The historical fact is that scientific interest was stimulated in them, and they were free to make the limited, piecemeal studies of the physical world which have been the hallmark of modern science and the way to its great accomplishments.

Therefore any attack on Christianity by means of *scientific* arguments is inherently contradictory. For example, science requires that nature can be understood, that man transcends nature and can be a neutral observer "outside the system," that uniformity is valid, and that truth is real. None of these can be justified by science, but all of them are by Christian theology. Even something as prosaic as the assumption that science can lead to truth arose from the Christian confidence that God's truth is manifested in what He made.

These inconsistencies (Figure 6) and the strategy for using them were described by Reed (1996a, 1996b, 1998a), Klevberg (1999), and Reed et al. (2004). More recent explanations are provided by Lisle (2009) and Sarfati (2010). Even Christians opposed to creation and those advocating intelligent design have realized this (e.g., D'Souza, 2008; Pearcy and Johnson, 2008). Logic and



ELEMENT	DESCRIPTION	JUSTIFICATION
Empirical & Inductive	Nature is investigated by observation and experimentation. No rational principal underlying phenomena.	God was absolutely free to create as He wished. Therefore, we understand it by looking at what He made, not by seeking a controlling principle.
Rational	Nature and the rules governing its operation will be rational. It will "make sense."	God is rational and wise. Therefore, creation will reflect those attributes. "Thinking God's thoughts after Him."
Cooperative	Disparate men can work on disparate details with the confidence that their work will all fit together.	Unity of truth depends on its unitary source...God. Bits and pieces of truth are still true.
Man, the scientist	Men can understand nature, standing outside the system as an objective observer. Failure to understand is an incentive to keep working, not give up.	Man, created in God's image, transcends nature. Dominion implies the capacity to comprehend what God has made.
Uniformity	Nature operates by regular principles that transcend time and space. "Laws" apply throughout the cosmos and time and are thus predictable.	God is immutable, infinite, and eternal. These attributes lead to the expectation of uniformity in what He made.

Figure 6. Examples of essential elements of science that are justified only by Christianity.

reason are effective at all levels (Day, 2008) but are deadliest when turned on presuppositions.

Despite this gaping hole in their logic, many Christians are distracted by secular natural history. They cannot emotionally accept the concept of a young earth, and incorrectly view a lengthy prehuman prehistory as a conclusion of empirical study rather than an assumption. However, Rudwick (2005) showed that deep time was the position of intellectuals *prior* to any of the so-called evidences of long ages, such as the geological timescale or radiometric dating. Prehistory was merely the manifestation of the prior secular rejection of God—primarily of His work of providence. Prehistory is thus linked to metaphysical naturalism and is dragged down by problems in its parent worldview. It is worth noting that the modern understanding of history also rests on Christian theology (Clark, 1994; Reed, 2000) in justifying axioms of linear time, uniformity, and the importance of history.

If the presuppositions of naturalism are justified only by Christianity, then contradiction is demonstrated and naturalism as a worldview is formally invalid. It is upheld only by the faith commitments of its devotees and by cultural inertia—an ironic reversal of the Enlightenment. With the prop of science gone, all that is left for atheists is wishful thinking. Because they cannot justify it through reason, they enforce it through tyranny (Bergman, 2008). For years, atheists have claimed that science is congenial to their materialistic, positivistic worldview. But what they like to present as the ultimate romance is more accurately described as intellectual rape.

Methodological Naturalism

Having finally woken up to the reality that naturalism is a failed worldview, a number of theistic scientists have rejected its metaphysical approach. However, they often do not follow the train of logic far enough. Like the Israelites, they are not "destroying the high places" (e.g., 1 Kings 22:43). One of today's "high places" is "methodological naturalism." Many Christians see it as a way to reject atheism while escaping the equally unpalatable (to them) option of biblical creation. Though cast as nothing more than the method of the early scientists, we cannot ignore either the historical links between the two "naturalisms" or the cultural effects of 200 years of secularism. Given the vastly different mindset (cf. prologue of Wells, 1993), it is not surprising that methodological naturalism has become something Newton would never accept.

Only a brief overview of the secular concept is necessary, since it is so prevalent in science and culture. However, Christian responses to methodological naturalism bear more scrutiny.

Secular Methodological Naturalism

For secularists, methodological naturalism is the logical extension of their worldview. Scientists ignore God because He does not exist. The method of science has been perverted into a gateway to atheism, as Simpson's quote documents. He separates science from theology or philosophy, and claims naturalism is a necessary assumption of science. As we noted, this stems from the view that science is the autonomous door to truth. Secular scientists agree with Simpson because it is congruent with their faith, and because they have been conditioned by education and training.

Some disagree with Simpson for various reasons. From Kuhn (1962) down to the present, there has been a strong critical reaction to the simplistic view of science generally taught today as the scientific method. Some question whether there even is a scientific method (Bauer, 1992), while others question whether the failure of demarcation criteria (Hogan, 2010; Laudan, 1983) means that science cannot even be adequately defined. Cultural inertia and public education have left the public with the antiquated confidence of Simpson, but postmodern subjectivism, the politicization of research, and the neo-Luddism of environmentalism are valid threats to the scientific enterprise.

One major reason for public skepticism is the divorce of science from ethics. Methodological naturalism emphasizes the separation of science from religion, yet only religion can provide ethical imperatives to guide difficult choices. Shallow pragmatism cannot. Secular ethics have failed, and the terror of science in the hands of the powerful is one lesson from the twentieth century that has taken root. The same medical advances that can save large numbers of people can also be used to kill them, and secularists have not built an encouraging track record of valuing human life and liberty (Bergman, 2002; Day, 2008).

Despite attempts to convince the public that there is no difference between modern methodological naturalism and the traditional method of science, that idea cannot stand close analysis. Pioneer scientists, such as Newton, did not see science as autonomous nor completely separated from philosophy and theology. They did not dismiss God as the ultimate cause of phenomena. There can be no other reading of their work (e.g., Morris, 1988).

Methodological naturalism forces uncomfortable questions for theistic scientists, including:

- Why does the Christian worldview have no apparent relevance to science?
- Why does the scientific method lead many people to conclude Christianity is false?
- Why must we ignore God to have science?
- Why does the method of science outweigh the goal of truth?

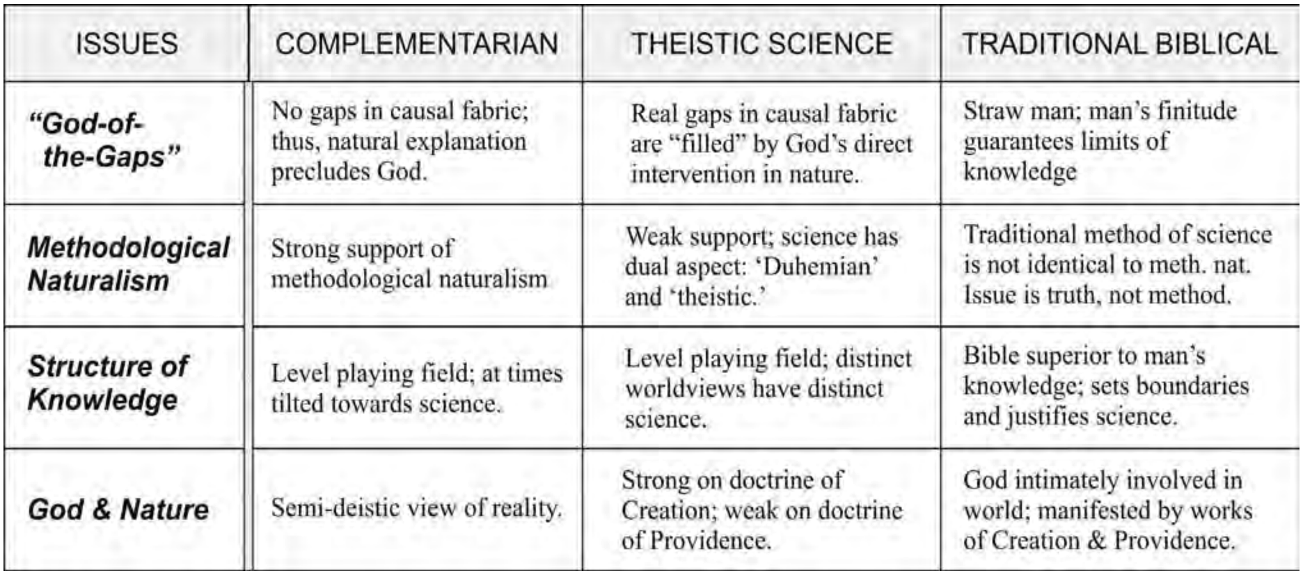
These issues are addressed by Christian thinkers in several ways.

Christian Views of Methodological Naturalism

Although all Christians by definition oppose metaphysical naturalism, they are strongly divided about naturalism as a method of science. Confusion among Christians often results from lingering positivism, opposition to creation science, and an inability to distinguish science from history. Poe and Mytyk (2007) claimed that the term "methodological naturalism" was coined by philosophy professor Paul de Vries of Wheaton College in 1986, although the concept was discussed in some depth by Glover, 1984, by Simpson, 1970, and many others much earlier.

De Vries committed an error that remains common. Rather than redeeming science from naturalism, he tried to sanctify naturalism in the scientific method. This mistake was repeated by Poe (2008), and in both cases they were driven by a perceived need to "triangulate" biblical creation and atheism. They are certainly not alone in the mistaken view that methodological naturalism is the "golden mean" between those two "extremes," and their error is twofold: (1) it assumes the creationist position is wrong at the outset, and (2) it ignores that man's relationship with God is always presented as an either/or choice (e.g., Matthew 12:30), not a sliding scale. Also, as we will see, it is not necessary.

There appear to be two major Christian approaches to methodological naturalism outside of traditional biblical orthodoxy (Figure 7): those of complementarians and theistic scientists. Unfortunately, there are creationists who inconsistently fall into both these camps,



ISSUES	COMPLEMENTARIAN	THEISTIC SCIENCE	TRADITIONAL BIBLICAL
"God-of-the-Gaps"	No gaps in causal fabric; thus, natural explanation precludes God.	Real gaps in causal fabric are "filled" by God's direct intervention in nature.	Straw man; man's finitude guarantees limits of knowledge
Methodological Naturalism	Strong support of methodological naturalism	Weak support; science has dual aspect: 'Duhemian' and 'theistic.'	Traditional method of science is not identical to meth. nat. Issue is truth, not method.
Structure of Knowledge	Level playing field; at times tilted towards science.	Level playing field; distinct worldviews have distinct science.	Bible superior to man's knowledge; sets boundaries and justifies science.
God & Nature	Semi-deistic view of reality.	Strong on doctrine of Creation; weak on doctrine of Providence.	God intimately involved in world; manifested by works of Creation & Providence.

Figure 7. Three ways in which Christians approach science and its method, based on Moreland, (1997); Plantinga (1997); Poe and Mytyk (2007); and this paper.

embracing methodological naturalism. In contrast, we assert that the traditional biblical view is true because (as we will show below) methodological naturalism is not one and the same as the attributes of science, and because of problems in both complementarian and theistic science approaches.

Complementarianism

This view is common currency among progressive creationists and theistic evolutionists. Poe and Mytyk (2007) list supporters as including Bube, Van Till, Miller, and many others. In many ways, it is indistinguishable from the secular view of methodological naturalism; it simply refuses to push the logic of ignoring God from science into a more general worldview. Complementarians also embrace a vague, yet pervasive positivism.

Poe (2008) traces the complementarian view to Francis Bacon's definition of science, in spite of his unrealistic optimism regarding human neutrality and objectivity. Complementarians argue that science requires the presumptions of purely natural causes for physical processes, primarily in reaction to "god-of-the-gaps" accusations by secularists (Moreland, 1997). This assumes that "natural" causes are, in fact, purely natural. In claiming this, and in asserting the absence of "gaps" in the causal fabric, they default to a semi-deistic view of nature (at best) and a level playing field between science and religion. This dovetails with Horton's (2008) assertion that much of modern evangelicalism is actually therapeutic deism. The deistic view encourages the error of thinking that science is the only legitimate mode of inquiry into Earth's past.

Creationists are not immune from these tendencies. Because the modern creation movement began as an attack *within* science, there remains a tendency by some to think that creation and the Flood can be explained scientifically … as witnessed by a proliferation of "Flood models." We suspect that confidence in methodological naturalism would go hand in hand with a view that natural history is a facet of natural science. For example, Brown (2008, p. 116) described his approach to natural history:

> To explain scientifically an unobserved event that cannot be repeated, we must first assume the conditions existing before that event. From these assumed starting conditions, we then try to determine what should happen according to the laws of Physics.

But the Bible explicitly teaches that God works in nature through both primary and secondary causes; thus defaulting to "laws of Physics" at best ignores one aspect of God's actions.

Theistic Science

Some Christians have recognized the dangers of the slippery slope between methodological naturalism and its metaphysical doppelganger. Glover (1984) traced the historical progression. Plantinga (1997, p. 143) called methodological naturalism "provisional atheism." He and others like Moreland (1997) and Meyer see several fundamental problems with the complementarian view. We will focus on Plantinga's (1997) argument, because it avoids the convolutions of Moreland (1997) or the attempt by Potter (1999) to introduce unnecessary new categories; i.e., "parascience" and "ultrascience" into the discussion.

Plantinga's basic rationale for "theistic science" comes from the reality of spiritual warfare. He recognizes the essential tension between worldviews and asserts that Enlightenment atheism tries to cover its tracks.

> According to an idea widely popular ever since the Enlightenment, however, science … is a cool, reasoned, wholly dispassionate attempt to figure out the truth about ourselves and our world, entirely independent of ideology, or moral convictions, or religious or theological commitments.… But many other areas of science are very different; they are obviously and deeply involved in this clash between opposed worldviews (Plantinga, 1997, p. 143).

He notes three arguments for methodological naturalism. The first, the "faith vs. reason meme of the Enlightenment" is easily dismissed.

> One root of this way of thinking about science is a consequence of the modern foundationalism stemming from Descartes and perhaps even more importantly, Locke. Modern classical foundationalism has come in for a lot of criticism lately.… And since the classical foundationalism upon which methodological naturalism is based has run aground, I shall instead consider … [other] reasons for accepting methodological naturalism (p. 145).

The second is Ruse's argument that it is true by definition. Plantinga asserts that it fails on three fronts: (1) the demarcation problem (cf. Hogan, 2010), (2) atheism's inability to justify natural law, and (3) a suspicion that the solution is more complex than mere semantics.

He then addresses the third argument—"functional integrity"—by reference to Van Till.

> Now Van Till suggests that God does nothing at all in the world *directly*; only *creatures* do anything directly. But no doubt Van Till, like any other theist, would agree that God directly conserves the world and all its creatures in being; he is directly active in the Big Bang, but also in the sparrow's fall.… And no doubt Van Till would also agree (on pain of infinite regress) that if God does anything in the world indirectly, he also does something directly: presumably he cannot cause an effect indirectly without also, at some point, acting directly.… Perhaps his idea is that God created the universe at some time in the *past* (acting directly at that time) but since then he never acts directly

> in the world, except for conserving his creation in being, and miracles connected with salvation history…. What is the warrant for supposing God no longer acts directly in the world? (Plantinga, 1997, p. 146).

Why do some Christians advocate this deistic framework? Plantinga (1997, p. 147, emphasis his) suggested that, "there is a different and unspoken reason for this obeisance to methodological naturalism: *fear and loathing of God-of-the-gaps theology*." Moreland (1997) echoed that observation. Plantinga (1997, pp. 148–149, emphasis his) then criticized that mind-set.

> Indeed, the whole *interventionist* terminology—speaking of God as *intervening* in nature, or *intruding* into it, or *interfering* with it, or *violating* natural law—all this goes with God-of-the-gaps theology, not with serious theism.… Indeed, the whole God-of-the-gaps issue is nothing but a red herring in the present context.

Having argued against methodological naturalism, Plantinga attempts to promote a dualistic model with two distinct kinds of science— "Duhemian science," named for the early twentieth-century historian of science Pierre Duhem (cf. Glover, 1984), and "theistic science," or "Augustinian science." Duhem recognized science as subordinate to metaphysics but was practically segregated to protect it from "metaphysical squabbling" and to ensure that it is a universal pursuit common to all men. That is much closer to the reality of the seventeenth century than "methodological naturalism" (Figures 4 and 5). Both Plantinga and Poe (2008) argue that science is about preserving objectivity, not furthering naturalism. But Clark (1994, p. 245), noted the impossibility of neutrality:

> There is also an element within every paradigm that Kuhn says is "arbitrary." When this element is seen in past periods of science, it is called "myth." However, it is no doubt present within contemporary paradigms without being recognized as mythical or erroneous.

This is problematic because:

> Many of the best scientists work their whole lives without ever seriously questioning the truth of the presuppositions their work rests upon. This must certainly be part of the reason why so many scientists insist dogmatically upon the truth of a naturalistic worldview while that worldview remains nothing more than a philosophical position outside the reach of scientific verification or falsification (Clark, 1994, p. 246).

He blamed it on education and training:

> We can see from this that what takes place in the training of scientists is a very thorough conditioning process.… And the over-arching metaphysical aspect of today's paradigm is hands down that of naturalism. It is impossible to conceive that that conditioning process does not result in a tremendous amount of absorption of naturalistic thinking by the scientists in training (Clark, 1994, p. 249).

At this point, theists have two alternatives: recapturing science from secularism or Plantinga's call for a distinct Christian enterprise, called "Augustinian science," operating in parallel with "Duhemian science." The former would be science based overtly on Christian metaphysics, and each science would have its own sphere.

> So there is little to be said for methodological naturalism. Taken at its best, it tells us only that Duhemian science must be metaphysically neutral and that claims of direct divine action will not ordinarily make for good science.… Perhaps we should join others in Duhemian science; but we should also pursue our own Augustinian science (Plantinga, 1997, p. 151).

This is closer to traditional science than the complementarian view because it recognizes the shortcomings of methodological naturalism. Plantinga's strength is seen in the weakness of his opponents, for example, Krause (1997). Krause offered four objections to Plantinga, ranging from weak to silly (i.e., blaming the Enlightenment on Christian intransigence; cf., Stark, 2003 for a rebuttal).

Moreland (1997) also argued against the complementarians but fell into the trap of arguing from secular premises. He claimed reality is a natural fabric with ontological causal gaps that point to God's direct intervention. Science is thus the process of identifying God's work in nature by pinpointing these gaps.

> One way this commitment [to theism] can appropriately enter the practice of science is through various uses in scientific methodology of gaps in the natural world. These gaps are essential features of direct, immediate, primary divine agency properly understood (Moreland, 1997, p. 2).

As expected, one reason for his wrong turn is his failure to differentiate between history and science in natural history investigations.

> The goal of natural science is to study the spatiotemporal natural world of matter and energy and seek natural explanations for the physical properties, behavior, and *formative history of the physical universe* (Moreland, 1997, p. 3, emphasis added).

Brand (1996, 2006) approached these issues as a creationist. He blamed the growth of the worldview of naturalism on science's progressive explanation of what were once considered mysteries. Glover (1984, p. 94, emphasis added) disagreed:

> It is, therefore, one of the *supreme ironies of modern culture* that this mechanistic method should have given rise early in its history to a mechanistic metaphysics that ne-

> gated its basically nonmetaphysical nature.

Brand (1996, p. 25) then repeated secular propaganda.

> The progress of the last two centuries tells us that naturalism has resulted in scientific progress. Whether or not we agree with the tenets of naturalism, it is unreasonable to say that naturalism is not an effective paradigm.

But naturalism cannot be an effective paradigm because there has been a tremendous inefficiency represented by the staggering amount of research wasted on its false ideas—evolution, geological history, extraterrestrial life, etc. Brand (1996, p. 26) was skeptical of solving the argument between the different Christian views: "Can the concepts of naturalism or interventionism be tested? The answer in both cases is no." Actually, both can—but by *logical* truth tests, not scientific ones.

In 2006, Brand expanded his discussion, introducing three models of science and religion. These included:

- No relationship between science and religion. Science provides truth; theology does not. Brand rejects the positivist tunnel vision of science, noting that it is a search for objective truth, not a game won by methodology.
- Science and religion are parallel but separate. Both provide truth, but science can critique religion while religion cannot return the favor. This view is popular with many Christians because it avoids overt naturalism as well as open conflict with the scientific establishment. Brand rightly argues that these Christians fail to understand both inherent weaknesses in science and sin's noetic influence.
- Interaction between science and religion. Both are sources of truth and should interact.

Brand rejected the first two and argued for the third. He made an important point in calling for science and religion to cooperate in the quest for truth. His figure 2 summarizes his views on integrating the two domains.

Although Brand made many good points, he appeared to place science and Christianity on a level playing field. This view is supported neither by history nor logic. In both cases, we see that science is contingent upon theology, and therefore subordinate to it. Secular positivism and its accompanying arrogance are not resolved by making Christianity the epistemic equal of science; it is, instead, inferior. This does not mean that it is not a powerful approach to truth in the physical realm. Clearly it is. That power should make us less, rather than more, contemptuous of the means by which it is justified.

Although the theistic science views of Plantinga and Moreland and the interactive model of Brand are all improvements on the complementarian view, they do not heal all the injuries of Enlightenment secularism. As we will argue below, that can only be done by uprooting its pervasive memes about the nature of science, history, and theology. Only a return to traditional biblical orthodoxy can accomplish this task. However, before we discuss the solution, we must address the red herrings of miracles and the "god-of-the-gaps" accusation.

Miracles and God-of-the-Gaps: False Dilemmas

Far too often, Christians react to naturalism like linebackers responding to a play-action fake. We shed blocks and stone the running back … only to discover that he doesn't have the ball—it is in the hands of a receiver dancing in the end zone. Arguments about miracles and "god-of-the-gaps" reasoning are important but tend to be the running backs that allow unaddressed presuppositions of naturalism to score against Christianity. We lose when secularists define the rules. Instead, we must force them to defend their axioms (Lisle, 2009; Reed, 2001; Reed et al., 2004). The most useful aspect of discussions of miracles and "god-of-the-gaps" reasoning is in the way they illustrate the need for a new strategy.

Miracles

Unbelievers have always argued against miracles because miracles certify revelation, obliging obedience. Modern secular arguments are typically traced to Hume (1977) who deemed miracles impossible because an empirical approach to knowledge required repeatability to confirm physical relationships. Or as Flew (1997, p. 49) noted:

> The basic propositions are, first, that the present relics of the past cannot be interpreted as historical evidence at all unless we presume that the same fundamental regularities obtained then as still obtain today.

Enlightenment secularists seized on Hume's arguments and attacked the possibility of miracles. Christians have answered in books and articles too numerous to cite here. Very few, however, have defended miracles by challenging the contradictory assumptions of secularists, specifically with regard to uniformity (Reed, 1998a). As a result, many Christians seem embarrassed by the subject, and seek to keep miracles and science as far apart as possible. For example, Young and Stearley (2008, pp. 462–463) claimed:

> We suggest, however, that God is economical with miracles and that he has employed them mainly in the service of redemptive history.… Arbitrary, unobserved miracles performed during the work of creation would have had absolutely no impact on people and would not serve to confirm the presence of God or the pronouncement of the word because no one was there to observe them.… Biblical miracles like the virgin birth, the resurrection or Jesus' walking on water were powerful signs to the observers to confirm the

> divinity of Christ but such miracles have no bearing on the daily practice of scientific geology. Such miracles have no effect on historical reconstructions of the Earth's past, nor do they affect the laws of physics or the course of chemical reactions.… What would be a problem, however, is the introduction of arbitrary or capricious miracles with no compelling reason from the biblical text for assuming their existence. Assuming such miracles would make the pursuit of historical sciences more problematic.

Reed (2010a) noted a litany of errors in this statement. Rather than developing a better theology of miracles, Young and Stearley (2008) only show that fear of, and compromise with, secular arguments lead to retreat and further compromise.

The answer to secularists about miracles is both negative and positive. First, the negative answer is to challenge the assumptions on which the secular case is built. Once they are shown to be contradictory, then the case falls apart. For example, Geisler (1997, p. 84; brackets added) answered the argument from uniformity as follows:

> If this assumption is correct … one should not believe in the historicity of any unusual events from the past (since none are repeatable). Likewise, even historical geology is unrepeatable in practice, since the fossil record was formed only once and has not been repeated. So also is the history of our planet unrepeatable. Yet it has happened. Hence, if Flew [and Hume are] right, the science of geology should be eliminated, too!

Positively, Christians should argue that miracles fall within the domain of theology, not science, because miracles are God's direct causing of particular effects according to His will. Science, properly defined, deals *only* with the *normative* workings of providence, or what is commonly called "natural law." For that reason, scientific arguments against miracles are ultimately non sequitur.

God-of-the-Gaps

Weinberger (2008) presented a good summary of the "god-of-the-gaps" debate and recognized that theistic compromise with naturalism gives the argument its power.

> To maintain the acceptance of both [science and Scripture], conventional wisdom dictates that Scripture be separated from science. As I have attempted to show, it is precisely this separation that *created* the inconsistencies of theistic religion-and-science discourse. Into the void left by the absence of biblical history was inserted the deistic god-of-the-gaps (Weinberger, 2008, p. 125).

Brand (1996, p. 13) noted other problems:

> In reality the logic in the "god-of-the-gaps" concept was naïve and implies that if we can understand how something works, God does not have any part in it. A further implication is that if God is involved in some process, that process does not function through nature's laws.

At the risk of getting ahead of ourselves, a return to the traditional doctrines of Creation and Providence negates the power of this secular argument. Orthodox Christianity has always taught that God's interactions with His creation fall under two distinct categories. These are summarized, for example, by Question 14 of the Westminster Larger Catechism (emphasis added):

> Q. How does God execute his decrees?
>
> A. God executes his decrees in the works of *creation* and *providence*, according to his infallible foreknowledge, and the free and immutable counsel of his own will.

These two classes of God's works are united in their Author's eternal, infallible wisdom and will. But they are not one and the same, and one way of distinguishing them is by reference to causality. God's work of creation is distinct from any "natural" processes that we observe today in that it was done by the immediate, unique power of God (Genesis 1). Thus, like miracles, the study of origins is the domain of theology or metaphysics. The real "gap," and one that swallows all of naturalism's theories, is the attempt to argue from science what science can never explain. For example, the big bang theory starts with a number of assumptions about reality, as well as initial conditions of space, time, matter, and energy. None of these can be justified by science, other than being necessary to make the theory "work." That is not science; it is speculation. Only Christianity can justify both the assumptions and the initial condition (God) sufficient to explain the cosmos, and although the argument is subject to truth tests of logic (cf. Sproul et al., 1984), it is ultimately one of theology.

Regarding creation, accusations of "god-of-the-gaps" reasoning fail because there were no ontological "gaps." That is because God directly created the cosmos according to His will and design. There are epistemological gaps because humans are finite, but there is no special argument benefiting secularists in noting that self-evident truth. Furthermore, Christians have fewer "gaps" in their knowledge thanks to divine revelation of truth outside human experience. Creation exhibits a direct link between cause (God) and effect (cosmos) not subject to science. Since two millennia of Christian apologetics have shown it to be a reasonable, consistent, and powerful explanation, the accusation that we employ "god-of-the-gaps" reasoning fails. Scripture's power in this regard is seen in the hesitancy of people like James Hutton to debate origins; he tried to ignore it by setting it outside the bounds of his geotheory. It was an error for the church to not call him on that point, just as it remains an error for the church to not call cosmologists on the same weakness of the big bang or any cosmogonic theories.

Is the "god-of-the-gaps" argument a problem for inquiry apart from the miracle of creation? No—thanks to God's other great work of providence. Once again, causal gaps are eliminated because cause is unified in God's will. Despite secular attempts to separate causality in creation from God, He is no less immediate to, or responsible for, the history of the world than for its origin. God's work of providence does not exclude His prerogative to choose to work immediately and directly. However, by revelation we understand that He *chooses* to maintain the natural order in predictable regularities using secondary causes. But God is God; nothing precludes His direct, immediate causing of anything at anytime in any place… hence, the argument against miracles fails.

Ironically, the assertion that science is even possible comes from the same source that confirms that science will not be able to explain everything. It is a fallacy to preclude miraculous works out of hand (like Hume), because God is both a necessary and sufficient cause for any true miracle, and the absence of miracles thus demands the absence of God. It is "catch-22" for secularism; if God is absent, then the axioms of science cannot be justified, but if He is present, then His direct or even miraculous works are always potentially present. It will not do to accept a nebulous substitute for the hard reality of divine providence—typically the "god" of deism. God is not limited by men or nature; He does as He chooses.

God is not causally irrelevant, as secularists wish; nor is He causally removed, as some Christians assert. Instead, He is immediately involved in every motion of every quark in the universe. Science is possible only by reference to the theological distinction between primary and secondary causation (Sproul, 1989). God's use of secondary causes—built-in regularities in the properties of matter and their relationships—as the normative means of accomplishing His will—only certifies His efficiency; it does not remove Him from the equation. Thus, the worst nightmare of the secularist is real. God is omnipresent—sparrows do not fall nor do bosons transmit force apart from His will. As Weinberger (2008) noted, once our presuppositions revert to orthodox Christianity, the whole "god-of-the-gaps" argument becomes moot, if not ridiculous. There are no "gaps" in God's will, which is the ultimate causal force behind everything that comes to pass, whether caused in nature mediately or immediately.

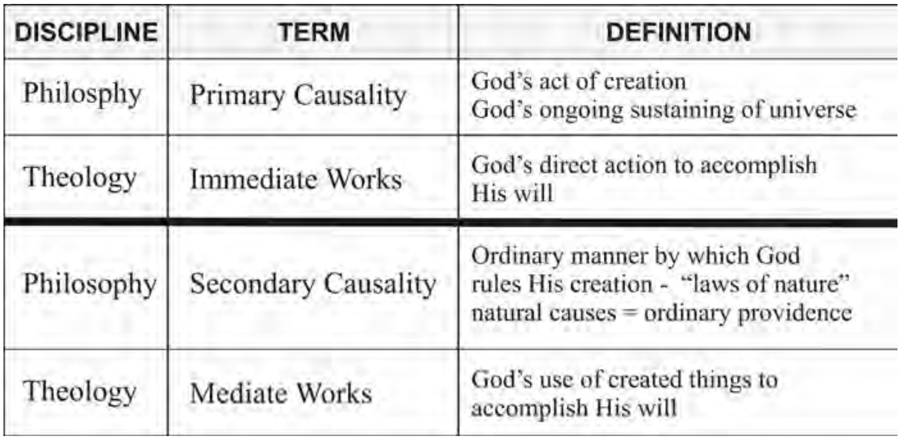
Another error in the debate is confusing metaphysics and epistemology. Secularists begin by defining "gaps" as failures in our *understanding* of particular causal nexi (epistemology), but they then leap right into real causality in nature (metaphysics). Sadly, many Christians allow themselves to become trapped in trying to explain the inexplicable workings of causality in the physical world (as opposed to assuming causality and explaining the resulting phenomena).

The whole argument can be boiled down to the simple statement that people do not understand as God does—a point made by theologians across the millennia. All the noise and bluster comes down to the amazing insight that the finite cannot comprehend the infinite. In modern parlance … *Duh*! The false premise behind this silly argument is that science and only science can ultimately comprehend the infinite. This is indefensible, and thus any argument along these lines is spurious. That Christians continue to wrestle with it is an embarrassment.

Providence: the Solution to Secular Pollution

The main point of this paper is that the orthodox understanding of providence negates the need for methodological naturalism, just as the doctrine of creation negates metaphysical naturalism. Providence provides a better Christian explanation for science and nature than those offered by the complementarians or advocates of theistic science.

To understand providence, we must understand the terms used by theologians on one hand and philosophers and scientists on the other. Sproul (1989)



DISCIPLINE	TERM	DEFINITION
Philosphy	Primary Causality	God's act of creation God's ongoing sustaining of universe
Theology	Immediate Works	God's direct action to accomplish His will
Philosophy	Secondary Causality	Ordinary manner by which God rules His creation - "laws of nature" natural causes = ordinary providence
Theology	Mediate Works	God's use of created things to accomplish His will

Figure 8. Differences between theological and philosophical language can causes confusion. The top two definitions refer to God's direct, often miraculous acts. The bottom two point to God's efficiency in ordinary providence in directing the workings of His creation, often subtly.

offered clarification between theological definitions of God's works and philosophical definitions of causality. Figure 8 shows two classes of God's works using both vocabularies. Sproul first drew the distinction between primary and secondary causality:

> Primary causality refers to God's act of creation as well as his ongoing work of sustenance over creation. His sovereignty stands over and above the created order at every moment. This makes him not only the Creator but the Lord of history as well. Secondary causality refers to what we commonly call the laws of nature. These "laws" reflect not an independent power of nature but rather the ordinary manner by which God rules his creation (Sproul, 1989, p. 67).

Then he discussed theological distinctives in the modes of God's work.

> Another crucial distinction that closely resembles the distinction between primary and secondary causality is the distinction between the immediate and mediate work of God. The term "immediate"… does not so much refer to "suddenness" as to a work directly done without intervening means (Sproul, 1989, p. 68).

The origin of scientific naturalism stems in part from the imprecise terminology of early scientists and philosophers—an excusable mistake because of the monolithic nature of the Christian worldview at that time. And it pales beside the errors of naturalism. These include errors of logic, a fuzzy positivism that inflates science beyond its bounds, a focus on method instead of truth, and a failure to distinguish history from science. But the foundational error is the assumption that God can be ignored. Recovering a seventeenth-century sense of divine immanence requires the doctrine of providence.

Providence as understood by Europe in the 1600s is largely rejected today. Poor theology abounds, for example, in Simpson's (1970, p. 61) attempt to justify naturalism by reference to James Hutton's uniformitarianism:

> He sharply distinguished First Cause from second causes. He was a providentialist in that he considered the First Cause as ordaining a terrestrial system the final cause of which is the benefit of its inhabitants, especially man, but he believed that the operation of that system, once it had been caused, was by entirely rational second causes with no preternatural intervention.

Hutton was no "providentialist"; he was a deist. It was Reformed scholars, using the philosophical terminology of Descartes, who applied the language of primary and secondary cause to describe modes of providence, most notably in the Westminster Confession of Faith (1647). In contrast to Hutton and Simpson, their view emphasized God's ongoing immanence and His constant control of both first and second causes. The God of orthodox Christianity did not create and retreat. As Paul noted in Acts 17:27–28, God is always at hand, providing life, motion, and being to all. Simpson's theological ineptness led to the contradiction: If God created, then He exists. If He exists, He is present, since part of being God is omnipresence. It is logically impossible for God to just go away! And thinking Him absent *some of the time* merely to affirm unbelief is irrational.

Simpson's worldview drove his thinking. What proves that nature's operation is entirely "rational," and what precludes "preternatural intervention?" On these issues science must be silent—a prospect that terrifies secular man. That is why secularism rages against orthodox understanding of both creation and providence—they take away the scissors that attempt to cut God out of the picture.

Unfortunately, there are Christians as inconsistent as Simpson, though in a different way. Like Hutton, they want a divine creation, but also like Hutton, they think the "second causes" of providence are inherent properties of matter. Sproul (1989, p. 67) warned against this error:

> What we call natural causes may also be called examples of ordinary providence. It is when we conceive of these secondary causes as being independent of God that we commit a form of idolatry.

Historical Understanding of Doctrine

We will examine the doctrine of providence at two points in time: (1) before the Enlightenment, and (2) at the height of the nineteenth century's secular tide. John Calvin (Figure 9) is considered the premier systematic theologian of the Reformation and was influential in the views of the seventeenth-century scientists, especially through the English Puritans who influenced the age of Newton. His *Institutes of the Christian Religion* (McNeil, 1960) would have been well known to all educated men in the 1600s.

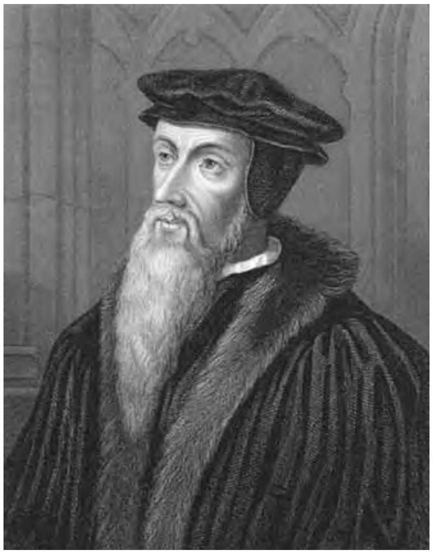


Figure 9. John Calvin (1509–1564) followed Martin Luther's reformation, becoming its premier systematic theologian.

Calvin first noted that both the original existence and ongoing operation of natural phenomena are chained to divine will.

> And considering inanimate objects we ought to hold that, although each one has by nature been endowed with its own property, yet it does not exercise its own power except in so far as it is directed by God's ever-present hand. These are … instruments to which God continually imparts as much effectiveness as he wills, and according to his own purpose bends and turns them to either one action or another (McNeill, 1960, p. 199).

Thus, pretending that physical phenomena have no causal connection to God is foreign to orthodox theology. Calvin noted that even those material actions we see as natural are under divine direction.

> God has witnessed by those few miracles [e.g., Joshua's long day; Isaiah's sign] that the sun does not daily rise and set by a blind instinct of nature but that he himself … governs its course (McNeill, 1960, p. 199, brackets added).

Then he addresses the immediacy and unlimited sweep of providential actions.

> And truly God claims … omnipotence—not the empty, idle, and almost unconscious sort that the Sophists imagine, but a watchful, effective, active sort, engaged in ceaseless activity. Not … a general principle of confused motion, as if he were to command a river to flow through its once-appointed channels, but one that is directed toward individual and particular motions. *For he is deemed omnipotent, not because he can indeed act, yet sometimes ceases and sits in idleness, or continues by a general impulse that order of nature which he previously appointed; but because, governing heaven and earth by his providence, he so regulates all things that nothing takes places without his deliberations* (McNeill, 1960, p. 200, emphasis added).

Calvin would have had had little patience for deism, as illustrated by his contempt for Epicureans.

> I say nothing of the Epicureans (a pestilence that has always filled the world) who imagine that God is idle and indolent (McNeill, 1960, p. 202).

Thus the seventeenth-century thinkers held a very different view of the world than modern secular man. God was the powerful Creator *and* the equally powerful Sustainer. He was there and could not be ignored. There was no skepticism of miracles, for through the lens of providence, everything was a wonder (Hooykaas, 1999). This was the view held by the early scientists.

> The regularities of nature were explained in terms of an order established by God and through which he *normally* acted in the world; this action of God was his *potentia ordinata* and it never circumscribed or limited the *potentia absoluta* which expressed his absolute freedom even in respect to the natural order he had established (Glover, 1984, p. 92).

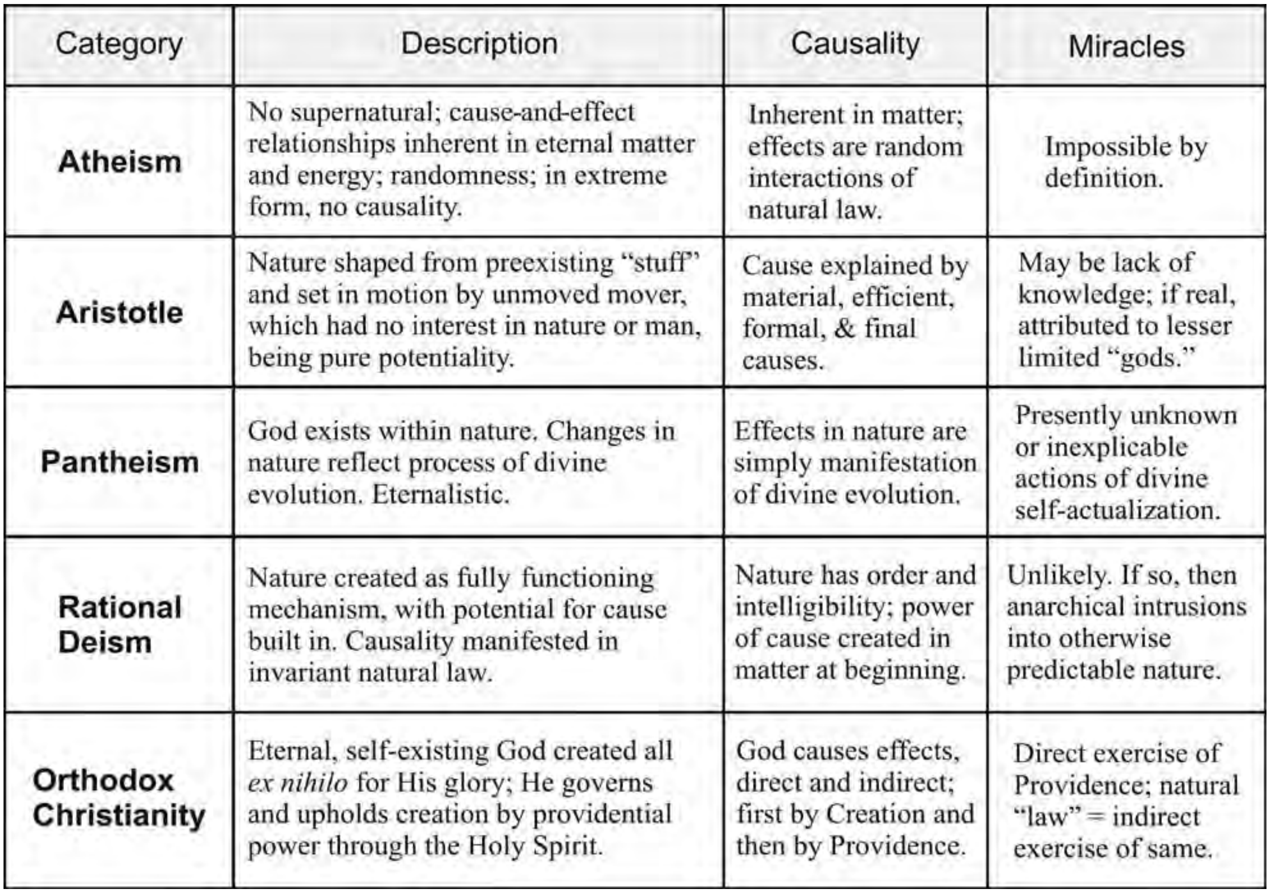
The possibilities of science, especially after Newton, combined with skeptical (Hume) and dogmatic (Kant, Hegel) philosophy, acted to diminish this view of God. In time, Enlightenment philosophy won the argument because Christians—too comfortable in their worldview to imagine competition—accepted secular premises. With providence transmuted to "laws of nature," creation could be dismantled by means of a lengthy prehuman prehistory and evolutionary development of species. "If the foundations are destroyed, what can the righteous do?" (Psalm 11:3 NASB).

Turning the clock ahead from Calvin to the 1800s, we examine the views of Robert L. Dabney (Figure 10), a prominent scholar in the tradition of Calvin. Unlike many of his peers, he recognized the danger of both Lyell and Darwin and their role in the growing secularism (Reed, 2010b). Dabney (1996, p. 276) retained Calvin's basic view:

Figure 10. Robert L. Dabney (1820–1898) was one of the ablest theologians of the nineteenth century. He grasped the danger of both biological and geological views of secular natural history and opposed both vigorously.

> We believe the Scriptures to teach, not only that God originated the whole universe, but that He bears a perpetual, active relation to it; and that these works of providence are "His most holy wise, and powerful preserving and governing all His creatures and all their actions."

Well educated in the history of ideas, Dabney framed different views of God's work in terms of traditional schools of thought, although he probably did not grasp the extent to which the unconscious incorporation of biblical presuppositions (Reed, 2001) separated modern secularism from pre-Christian alternatives (Glover, 1984). Dabney's different schools included Epicureans, rational deists, and pantheists. Figure 11 provides a summary of these and other relevant schools.



Category	Description	Causality	Miracles
Atheism	No supernatural; cause-and-effect relationships inherent in eternal matter and energy; randomness; in extreme form, no causality.	Inherent in matter; effects are random interactions of natural law.	Impossible by definition.
Aristotle	Nature shaped from preexisting "stuff" and set in motion by unmoved mover, which had no interest in nature or man, being pure potentiality.	Cause explained by material, efficient, formal, & final causes.	May be lack of knowledge; if real, attributed to lesser limited "gods."
Pantheism	God exists within nature. Changes in nature reflect process of divine evolution. Eternalistic.	Effects in nature are simply manifestation of divine evolution.	Presently unknown or inexplicable actions of divine self-actualization.
Rational Deism	Nature created as fully functioning mechanism, with potential for cause built in. Causality manifested in invariant natural law.	Nature has order and intelligibility; power of cause created in matter at beginning.	Unlikely. If so, then anarchical intrusions into otherwise predictable nature.
Orthodox Christianity	Eternal, self-existing God created all *ex nihilo* for His glory; He governs and upholds creation by providential power through the Holy Spirit.	God causes effects, direct and indirect; first by Creation and then by Providence.	Direct exercise of Providence; natural "law" = indirect exercise of same.

Figure 11. A summary of possible positions regarding God's action in the world.

According to Dabney, Epicureans admit an intelligent deity but claim that an emotional attachment to the world is inconsistent with his perfections, much like Aristotle's Unmoved Mover. Rational deists allow the Creator some interaction with His creation, but only in a vague and general way, mediated through natural law, like human rulers using stewards during an absence. Dabney was quick to note the shortcomings of rational deism: (1) human rulers command intelligent underlings, but God commands inanimate matter; (2) humans capture energy to do work, while God supplies His own; (3) any event that surprises God removes His omniscience and omnipotence; (4) if cause and effect rely on matter, then God's decree is reduced to the Stoic's fate; (5) God cannot direct general events without directing specific ones because the term "general" is an abstraction of particulars; and (6) if all events are connected by causality, and God is in that chain, then He must superintend each link or there would be no certainty in outcome. Of course pantheism disallows providence at the outset, since there is no distinction between God and the object of His work.

Dabney (1996, p. 279, emphasis added) rejected semantic confusion about "natural law."

> The much-abused phrase, law of nature, has been vaguely used in various senses… properly it means that it is the observed regular mode or rule, according to which a given cause, or a class of causes operates under given conditions.… *For nature is but an abstraction, and the law is but the regular mode of acting of a cause; so that instead of accounting for, it needs to be accounted for itself.*

But how could this regular mode of causation be explained? After all, scientific discoveries of past centuries had raised questions about God's interaction with the physical world. Dabney (1996, p. 280) saw two possible interpretations, both of which linked God to this causality, noting:

> But as to physical causes, orthodox divines and philosophers give different answers. Say the one class … matter is only passive. The coming of the properties of the cause into the suitable relation to the effect is only the occasion; the true agency is but God's immediately. All physical power is God directly exerting Himself through passive matter; and the law

> of the cause is but the regular mode which He proposes to Himself for such exertions of His power. Hence, the true difference between natural power and miraculous, would only be, that the former is customary under certain conditions, the latter, under those conditions, unusual.… Others … say that to deny all properties of action to material things is to reduce them to practical nonentity; leaving God the only agent and the only true existence, in the material universe. Their view is that God, in creating and organizing material bodies, endued them with certain properties. These properties He sustains in them by that perpetual support and superintendence He exerts. And these properties are specific powers of acting or being acted on, when brought into suitable relations with the properties of other bodies. Hence, while power is really in the physical cause, it originated in, and is sustained by, God's power.

So though science had raised philosophical questions about the exact mechanism of causality, the bottom line was still God. Note that Dabney (1996, p. 281) rejected the deistic position that seems to have evolved into the modern complementarian view.

> Some answer that God arranges the relationships between things, activating the potential for cause and effect. But this is no more than Leibnitz' pre-established harmony. This would, indeed, give the highest conception of the wisdom, power, and sovereignty exercised in establishing the amazing plan; but it would leave God no actual providential functions to perform in time, except the doubtful one of the mere sustentation of simple being.… This explanation is therefore obviously defective.

He concluded:

> Natural laws are simply the expression of a mode of consistent causal operation. But in nature, many laws work together to produce effects. Like man combining properties of various laws to create some novel mechanism, called rational contrivance for an end. Likewise, God (Dabney, 1996, p. 281).

During Dabney's day, secular attacks on miracles were unrelenting. Dabney replied, unwilling to accept the secular attempts to redefine terms:

> Providence is not strictly "supernatural" for that is God's acting beyond established natural causes, but it is supra physical, being personal. "For that which Personal Will effectuates through the regular laws of second causes, is properly natural.… Some think miracles are hidden laws. But this is inconsistent with their purpose of attesting revelation. We must hold fast to the old doctrines; that a miracle is a phenomenal effect above all the powers of nature; properly the result of … God's immediate power which He has not regularly put into any second causes, lower or higher.… Miracles are not anarchical infractions of nature's order.… Every miracle was wrought in strict conformity with God's decree (Dabney, 1996, pp. 282–283).

Then, he addresses the spirit of the nineteenth century directly.

> The natural rose out of the supernatural, and in that sense, reposes upon it at all times. The Divine will is perpetually present, underlying all the natural. Else God is shut back to the beginning of the universe, and has no present action nor administration in His empire. Reason: Because, if you allow Him any occasional, or special present interventions, at decisive crises, or as to cardinal events, those interventions are found to be, as events, no less natural than all other events (Dabney, 1996, p. 283).

Having tasted orthodox views of providence, let us examine how it specifically refutes both metaphysical and methodological naturalism.

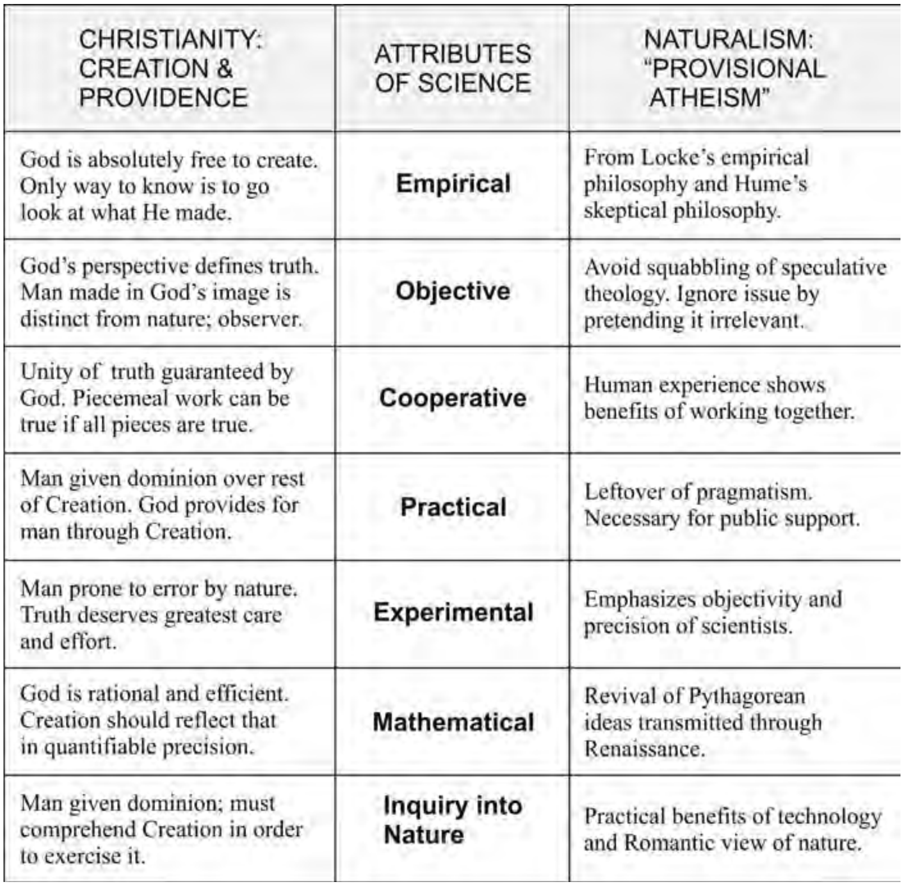
Providence versus Metaphysical Naturalism

The reason for deism is made clearer by understanding providence. Before Enlightenment atheism could overcome the doctrine of creation, it had to remove God from the immediate sphere of human existence, manifested through His providence. Dabney (1996, pp. 260–261) saw the key idea.

> Again, why should the Theistic philosopher desire to push back the creative act of God to the remotest possible age, and reduce His agency to the least possible minimum, as is continually done in these speculations? What is gained by it? Instead of granting that God created a … world, some strive continually to show that He created only the rude germs of a world, ascribing as little as possible to God, and as much as possible to natural law. *Cui bono*; if you are not hankering after Atheism?

Subsequent history has validated his insight—the "hankering" after atheism has been epidemic. And that is one reason the earliest assaults on orthodox Christianity were on biblical history, not origins. Once God was no longer intimately involved in His world, creation could be pushed back, resulting in a distant, uninvolved God. Human nature would then naturally progress toward atheism.

But the secularists made a fatal mistake in their carefully orchestrated distortions. They chose science as their champion, and although they successfully erected shields in the form of historical fables about science arising as a new classicalism overcoming Christian superstition (e.g., Bergman, 2003; Reed, 2008), they forgot that science had been built on axioms justified by, and only by, Christian theology. Science grew out of the theology of creation and providence. Thus, every time they attack orthodox Christianity, they attack themselves. Like Wile E. Coyote, every time they devised a clever plot to kill their enemy,



CHRISTIANITY: CREATION & PROVIDENCE	ATTRIBUTES OF SCIENCE	NATURALISM: "PROVISIONAL ATHEISM"
God is absolutely free to create. Only way to know is to go look at what He made.	**Empirical**	From Locke's empirical philosophy and Hume's skeptical philosophy.
God's perspective defines truth. Man made in God's image is distinct from nature; observer.	**Objective**	Avoid squabbling of speculative theology. Ignore issue by pretending it irrelevant.
Unity of truth guaranteed by God. Piecemeal work can be true if all pieces are true.	**Cooperative**	Human experience shows benefits of working together.
Man given dominion over rest of Creation. God provides for man through Creation.	**Practical**	Leftover of pragmatism. Necessary for public support.
Man prone to error by nature. Truth deserves greatest care and effort.	**Experimental**	Emphasizes objectivity and precision of scientists.
God is rational and efficient. Creation should reflect that in quantifiable precision.	**Mathematical**	Revival of Pythagorean ideas transmitted through Renaissance.
Man given dominion; must comprehend Creation in order to exercise it.	**Inquiry into Nature**	Practical benefits of technology and Romantic view of nature.

Figure 12. The essential elements of science do not require methodological naturalism. They are in fact fully justified and confirmed only by theology, particularly the doctrines of creation and providence. Methodological naturalism is an unnecessary accretion.

they overlooked key ideas, and ended up caught in their own trap.

Metaphysical naturalism cannot possibly be true. Creation and providence uphold a Christian view of reality that justifies science. Nothing else does. Since contradiction is the hallmark of the lie, the self-contradiction of naturalism marks it as a false system. No amount of science can change that. As Reed (1996a, p. 7) noted, "If you cannot possibly be right, why bother gathering empirical data?" Until advocates of naturalism can justify their axioms within their own materialistic metaphysic, then their worldview is invalid.

Any time an individual human being experiences God's action in his or her life, such as an answered prayer, an uplifted heart, or even the next breath, providence is affirmed. If God acts in this world according to His will, and if God is omnipotent, then the continuous, immanent work of God in every detail of this world is affirmed. That reality is the antidote to metaphysical naturalism.

Providence versus Methodological Naturalism

Plantinga (1997) called methodological naturalism "provisional atheism," and if there are gray areas in the theoretical argument, there can be no doubt that has been the practical result. Otherwise, how do we account for the innumerable tales of science seducing the church's youth away from the faith? Dabney (1996, p. 257) defined the bottom line.

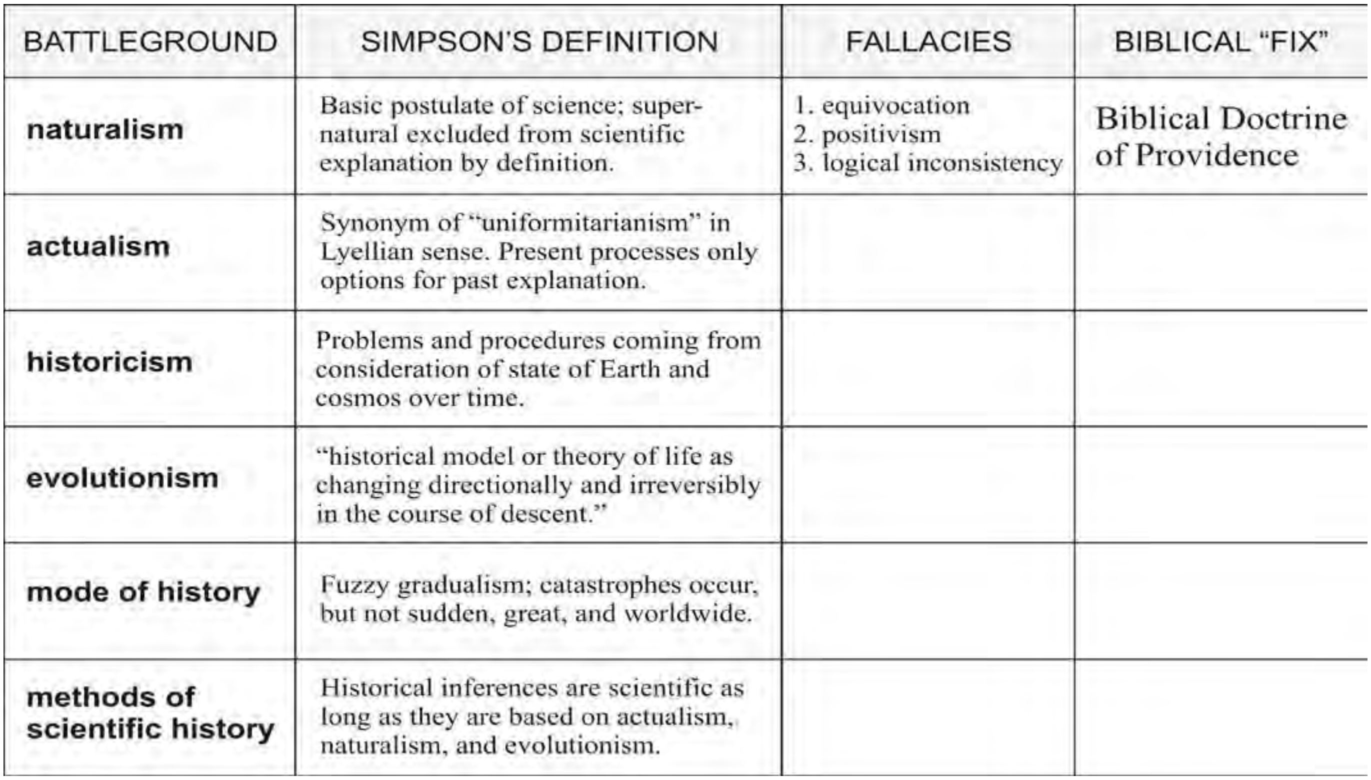
> If any part of the Bible must wait to have its real meaning imposed upon it by another, and a human science, that part is at least meaningless and worthless to our souls. It must expound itself independently; making other sciences ancillary, and not dominant over it.

The deceit of methodological naturalism is subtle because in some ways it closely resembles the classical method of science. But as we see in Figure 12, methodological naturalism is an unnecessary addition to the true attributes of science. In fact, these are all better justified by theology than by methodological naturalism.

While early scientists provisionally distanced the method of scientific inquiry from theological inquiry, they never separated science from theology. Instead, they remained aware of the very real links between the two, holding a view of providence that made God the final explanation, even if other causes were evident. Simply reading their works proves this. The subtlety of secularists is that they make a practical distinction into a theoretical separation and minimize this giant shift by playing up the autonomous power of science at the expense of theology.

Christians educated and trained in science imbibe this attitude early on, as well as that of metaphysical naturalism. Rejecting the latter, they see the former as a way to remain scientists in good standing with secular peers. They also see it as an antidote to creation science (Poe, 2008), the kiss of death vis-a-vis their secular peers. That methodological naturalism is used to oppose God's direct special revelation confirms its erroneous nature. "Has God said…?"

The method of science was developed to facilitate empirical, piecemeal, and objective inquiries into the workings of God's creation, recognizing God's providential superintending of it was



BATTLEGROUND	SIMPSON'S DEFINITION	FALLACIES	BIBLICAL "FIX"
naturalism	Basic postulate of science; supernatural excluded from scientific explanation by definition.	1. equivocation 2. positivism 3. logical inconsistency	Biblical Doctrine of Providence
actualism	Synonym of "uniformitarianism" in Lyellian sense. Present processes only options for past explanation.		
historicism	Problems and procedures coming from consideration of state of Earth and cosmos over time.		
evolutionism	"historical model or theory of life as changing directionally and irreversibly in the course of descent."		
mode of history	Fuzzy gradualism; catastrophes occur, but not sudden, great, and worldwide.		
methods of scientific history	Historical inferences are scientific as long as they are based on actualism, naturalism, and evolutionism.		

Figure 13. Answering the fallacies of the battlegrounds of natural history: naturalism. (Additional battleground fallacies will be added as they are addressed in later papers of this series.)

typically regular and predictable. Every aspect of science required Christian theology to justify assumptions; otherwise, as Stark (2003) noted, it would have developed elsewhere.

Providence and Miracles

Providence cuts through the fog surrounding modern discussions of miracles by changing the rules of the debate. By rejecting deism, we reject the "whether or not" God can or would do a miracle in the abstract. Instead, we regain that wondrous sense that *everything* is miraculous in the sense that God is acting continuously and omnipotently in space and time. We reject the categories "natural" and "supernatural" in explanation and return to the categories of "God's direct immanent action" and "God's indirect immanent action." God governs His creation; our only question is whether events represent the regular maintenance of secondary causes or a direct intervention in the created order, even if it overrides those regularities. In doing so, we readmit theology to the table, restrain the hubris of science, and refocus on the goal of both—truth.

We have already discussed how the doctrine of providence dispels the fog of the "god-of-the-gaps" accusations.

In summary, an orthodox understanding of providence is the antidote to naturalism of all types and illustrates the spurious nature of the ancillary red herrings of miracles and "god-of-the-gaps" accusations that have distracted Christians for two centuries. In answer to Simpson and his secularist peers regarding naturalism, we affirm that it is not a requirement for science and that any metaphysical manifestation in an attack on Christianity is a self-refuting argument. Furthermore, the corollaries of positivism and "scientific history" are rejected as inconsistent with this doctrine and its implications (Figure 13).

Conclusion

Naturalism in all forms must be opposed by Christians. As we have seen, a firm grip on the biblical doctrine of providence is an antidote to that intellectual poison. It refutes metaphysical naturalism in redirecting attention to the Christian presuppositions that permeate modern atheism. It also obviates the need for "methodological naturalism" because it is silly to assume God out of the picture when the biblical view is that God *is* the picture.

Secular "natural laws" are shown to be the regularities of God's providential care for His creation. They do not preclude God's direct action in space and time, even contrary to those regularities, because omnipotence is a prerequisite of providence and by definition that means that God is free to act however He wills. All of the attributes of science that supposedly require methodological naturalism are better defined and justified by Christian theology. Providence also answers the skeptical denial of miracles and the deistic view of minimalist "intervention." It also shifts our perspective on secular accusations of "god-of-the-gaps" reasoning. There are no ontological gaps because cause is united in the will of God. Epistemological gaps are endemic to the human condition of finitude and thus are no argument for or against any particular position.

Finally, providence drives us back to revelation, refuting the cultural positivism that renders science the doorway to truth. Limiting the boundaries of science also helps us understand that history is distinct from science, and so natural history must find its own methods and rules, eliminating the scientific certainty with which we are told about prehistory and evolution. Needless to say, the implications of the doctrines of creation and providence refute those two ideas too.

This perspective is contrary to the secular consensus of the West, demonstrating our original contention—that this topic is a battleground between two worldviews, one that Christians would do well to battle from the strong position of biblical orthodoxy.

Glossary

Creation—The work of creation is that wherein God did in the beginning, by the word of his power, make of nothing the world, and all things therein, for himself, within the space of six days, and all very good (*Westminster Larger Catechism*, Answer 15).

Epistemology—Branch of philosophy that deals with the nature of knowledge.

"God of the gaps"—Accusation by secularists that Christians explain the unknown by reference to God. Supposedly, as science progresses, "gaps" decrease until God is no longer necessary.

Immediate works—Refers to Gods' direct causing of particular events; parallel to primary causality.

Mediate works—Refers to God's indirect causing of particular events; parallel to secondary causality.

Metaphysics—Branch of philosophy that deals with the nature of being and reality.

Metaphysical naturalism—Atheistic worldview or sometimes the metaphysical component of that worldview.

Methodological naturalism—Assumption by science that physical phenomena are explained by innate physical laws of nature.

Positivism—Epistemological position that truth comes through science, not theology.

Primary causality—Refers to God's direct action in causing something to come to pass.

Providence—God the great Creator of all things does uphold, direct, dispose, and govern all creatures, actions, and things, from the greatest even to the least, by His most wise and holy providence, according to His infallible foreknowledge, and the free and immutable counsel of His own will, to the praise of the glory of His wisdom, power, justice, goodness, and mercy (*Westminster Confession of Faith*, IV–I).

Secondary causality—Refers to God's use of secondary causes in events. For example, God saved Jonah's life by using a large sea creature.

References

CRSQ: Creation Research Society Quarterly

PSCF: Perspectives on Science and Christian Faith

Adler, M.J. 1992. *A Second Look in the Rearview Mirror*. Macmillan. New York, NY.

Bauer, H.H. 1992. *Scientific Literacy and the Myth of the Scientific Method*. University of Illinois Press, Urbana, IL.

Bergman, J. 2002. Darwinism as a factor in the twentieth-century totalitarianism holocausts. *CRSQ* 39:47–53.

Bergman, J. 2003. The Galileo myth and the facts of history. *CRSQ* 39:226–235.

Bergman, J. 2008. *Slaughter of the Dissidents*. Leafcutter Press, Southworth, WA.

Brand, L.R. 1996. The paradigm of naturalism, compared with a viable alternative: a scientific philosophy for the study of origins. *Origins* 23(1):6–34.

Brand, L.R. 2006. A Biblical perspective on the philosophy of science. *Origins* 59:6–42.

Brown, W.T. 2008. *In the Beginning: Compelling Evidence for Creation and the Flood*, 8th edition. Center for Scientific Creation, Phoenix, AZ.

Clark, J.P. 1994. Fact, faith, and philosophy: one step toward understanding the conflict between science and Christianity. *PSCF* 46:242–252.

Dabney, R.L. (1878) 1996. *Systematic Theology*, 2nd edition. Presbyterian Publishing Co. of St. Louis, St. Louis, MO. Reprint, Banner of Truth Trust, Carlisle, PA.

Dawkins, R. 2006a. *The God Delusion*. Bantam Press, London, UK.

Dawkins, R. 2006b. The Cydonia Group declares war on religion (December 15, 2006). Press release from http://www.positiveatheism.org/hist/quotes/dawkins.htm (accessed January 2010).

Day, V. 2008. *The Irrational Atheist*. Benbella Books, Dallas, TX.

D'Souza, D. 2008. *What's So Great About Christianity*. Tyndale House Publishers, Carol Stream, IL.

Flew, A. 1997. Neo-Humean arguments about the miraculous. In Geivett, R.D., and G.R. Habermas (editors), *In Defense of Miracles*, pp. 45–57. InterVarsity Press, Downers Grove, IL.

Geisler, N. 1997. Miracles and the modern mind. In Geivett, R.D., and G.R. Habermas (editors), *In Defense of Miracles*, pp. 73–85. InterVarsity Press, Downers Grove, IL.

Glover, W. 1984. *Biblical Origins of Modern Secular Culture*. Mercer University Press, Macon, GA.

Gould, S.J. 1997. This view of life: nonoverlapping magisteria. *Natural History* 106(2):16,18–22,60–62.

Harris, S. 2004. *The End of Faith*. W.W. Norton & Co., New York, NY.

Harris, S. 2006. *Letter to a Christian Nation*. Knopf, New York, NY.

Hitchens, C. 2007. *God is not Great*. Twelve, New York, NY.

Hogan, T. 2010. Some implications of the demise of the demarcation problem. *CRSQ* 46:167–176.

Hooykaas, R. 1972. *Religion and the Rise of Modern Science*. Regent College Publishing, Vancouver, Canada.

Hooykaas, R. 1999. *Fact, Faith and Fiction in the Development of Science: The Gifford Lectures Given in the University of St Andrews 1976*. Kluwer Academic Pub, Norwell, MA.

Horton, M. 2008. *Christless Christianity: The Alternative Gospel of the American Church*. Baker Books, Grand Rapids, MI.

Hume, David. (1748) 1977. *An Inquiry Concerning Human Understanding*. Reprint, Hackett Publishing Company, Indianapolis, IN.

Keller, T. 2008. *The Reason for God: Belief in an Age of Skepticism*. Dutton Publishers, New York, NY.

Klevberg, P. 1999. The philosophy of sequence stratigraphy part I—philosophic background. *CRSQ* 36:72–80.

Krause, D.J. 1997. Response to Plantinga. *PSCF* 49:285–286.

Kuhn, T.S. 1962. *The Structure of Scientific Revolutions*. University of Chicago Press, Chicago, IL.

Laudan, L. 1983. The demise of the demarcation problem. In Cohen, R.S., and L. Laudan (editors), *Physics, Philosophy, and Psychoanalysis*, pp. 111–127. Reidel, Dordrecht, Holland. Reprinted in Ruse, M., and R. Pennock (editors). 2009. *But Is It Science?* pp. 312–330. Prometheus Books, New York, NY.

Lisle, J. 2009. *The Ultimate Proof of Creation*. Master Books, Green Forest, AR.

McNeil, J.T. (editor). 1960. *Calvin: Institutes of the Christian Religion*. Translated and Indexed by F.L. Battles. Westminster Press, Philadelphia, PA.

Moreland, J.P. 1997. Complementarity, agency theory, and the God-of-the-Gaps. *PSCF* 49:2–14.

Morris, H.M. 1974. *The Troubled Waters of Evolution*. Creation-Life Publishers, San Diego, CA.

Morris, H.M. 1988. *Men of Science Men of God: Great Scientists of the Past Who Believed the Bible*. Master Books, San Diego, CA.

Mortenson, T. 2004. *The Great Turning Point: The Church's Catastrophic Mistake on Geology before Darwin*. Master Books, Green Forest, AR.

Pearcey, N.R., and P.E. Johnson. 2008. *Total Truth: Liberating Christianity from its Cultural Captivity*. Crossway Books, Wheaton, IL.

Plantinga, A. 1997. Methodological naturalism? *PSCF* 49:143–154.

Poe, H.L. 2008. Poe replies. *PCSF* 60(1):41–42.

Poe, H.L., and C.R. Mytyk. 2007. From scientific method to methodological naturalism: the evolution of an idea. *PSCF* 59(3):213–218.

Potter, H.D. 1999. How to end science's border war: a conceptual framework. *PSCF* 51(2):98–101.

Reed, J.K. 1996a. A Biblical Christian framework for earth history research: part I—critique of the naturalist-uniformitarian system. *CSRQ* 33:6–12.

Reed, J.K. 1996b. A Biblical Christian framework for earth history research: part II—foundation and method of historical analysis within the Biblical Christian system. *CSRQ* 33:210–216.

Reed, J.K. 1998a. Demythologizing uniformitarian history. *CRSQ* 35:156–165.

Reed, J.K. 1998b. Trigger finger on a shaky gun—Stephen Jay Gould's "take" on papal epistemology. *CRSQ* 34:239–242.

Reed, J.K. 2000. Historiography and natural history. *CRSQ* 37:160–175.

Reed, J.K. 2001. *Natural History in the Christian Worldview*. Creation Research Society books, Chino Valley, AZ.

Reed, J.K. 2008. St. Hutton's hagiography. *Journal of Creation* 22(2)121–127.

Reed, J.K. 2010a. Untangling uniformitarianism, level I: a quest for clarity. *Answers Research Journal* 3:37–59.

Reed, J.K., and P. Klevberg. In press. Geotheory: past and present. *CRSQ*.

Reed, J.K. 2010b. Robert L. Dabney: a rock in the storm of nineteenth-century natural history. *Journal of Creation* 24(3):122–127.

Reed, J.K., P. Klevberg, C.B. Bennett, C.R. Froede Jr., A.J. Akridge, and T.L. Lott. 2004. Beyond scientific creationism. *CRSQ* 41:216–230.

Rudwick, M.J.S. 2005. *Bursting the Limits of Time: The Reconstruction of Geohistory in the Age of Revolution*. University of Chicago Press, Chicago, IL.

Sarfati, J. 2010. Why does science work at all? http://creation.com/science-biblical-presuppositions (accessed August, 2010).

Simpson, G.G. 1970. Uniformitarianism. An inquiry into principle, theory, and method in geohistory and biohistory. In Hecht, M.K., and W.C. Steere (editors), *Essays in Evolution and Genetics*, pp. 43–96. Appleton-Century-Crofts, New York, NY.

Sproul, R.C. 1989. Providence, science, and the sovereignty of God. *PSCF* 41:67–68

Sproul, R.C., J. Gertsner, and A. Lindley. 1984. *Classical Apologetics: A Rational Defense of the Christian Faith and a Critique of Presuppositional Apologetics*. Academie Books, Grand Rapids, MI.

Stark, R. 2003. *For the Glory of God*. Princeton University Press, Princeton, NJ.

Weinberger, L. 2008. Whose god? The theological response to the god-of-the-gaps. *Journal of Creation* 22(1):120–127.

Wells, D. 1993. *No Place for Truth or Whatever Happened to Evangelical Theology?* Wm. B. Eerdmans Publishing Company, Grand Rapids, MI.

Westminster Larger Catechism. http://www.reformed.org/documents/larger1.html (accessed August, 2010).

Young, D., and R. Stearley. 2008. *The Bible, Rocks, and Time*. InterVarsity Press, Downers Grove, IL.

The Case for the Mature Creation Hypothesis

Jerry Bergman*

Abstract

***Ex-nihilo* creation from nothing always results in all created objects having the appearance of maturity. This is true for every creation from functional life to a functional universe. The assumption that natural processes operated during Creation just as they do now leads to an “appearance of age.” The appearance-of-age concept is explored, showing that this conclusion applies to all miracles, including everything from the creation of wine from water to the creation of Adam and Eve from dust. This view fits both the scriptural record and the scientific data. It also has a long history and in modern times has been advocated by many creationists and Biblical scholars from Philip Gosse to Henry Morris.**

Introduction

A concept that has a long history in Christianity is called mature creation or a “coherently mature universe,” “functional completeness,” “prochronism,” meaning outside of time, “created fully grown,” or the “appearance of maturity when created.” Just as a sphere must have three dimensions, reality requires that both physical and biological creations, according to assumptions based on present process rates, display to human observers the appearance of age from the objects’ first material existence.

This theory may account for the discrepancy between the age that scientists have determined for various aspects of creation and the age that Genesis presents. This paper argues that this discrepancy is an unavoidable result of the false assumption that the world operated during its creation exactly as it does now. A second concern is that miracles by definition require an event that scientific research has proven impossible; otherwise the event would not be a miracle. The concept of apparent age is, in part, a viable explanation for these conflicts.

Creation ex-nihilo

The basis of the appearance-of-age conclusion is the Creation ex-nihilo doctrine common to Christian, Jewish, and Muslim theology (Reymond, 1998). This fundamental Biblical doctrine is supported by many Scriptures, including Colossians 1:16, 17; John 1:3; and Exodus 20:11. This doctrine is important for several reasons. Plato and other ancient sages taught that God created the world but that He created it from previously existing material, whereas Christianity taught that God created it out of nothing, a view called *Creation ex-nihilo* (Hannam, 2009, p. 63).

Creation ex nihilo is not a minor doctrine, but a central plank in Christian theology. The Greeks and others believed that God created the universe from preexisting chaos that was difficult to remake like new; consequently, the universe that resulted was not as perfect as the original forms on which the Creator based His design (Hannam, 2009, p. 63).

In contrast, Christianity taught that God created the universe from nothing, thus the creation was not a remake of something old, but rather was the cre-

---

* Jerry Bergman, PhD, Biology Department, Northwest State College, Archbold, OH
Accepted for publication April 3, 2011

ation of something that was new and that Genesis says was "very good." This is important for the doctrines of the Fall of mankind into sin and death described in Genesis and Jesus' sacrifice to restore humankind. As Hannam notes,

> Both pagan and Christian would agree that the world is not perfect, but the Platonist would blame the material the creator had to use, while the Christian would believe that it was created perfect and only fell later due to human actions (Hannam, 2009, p. 41).

The conclusion that God created the universe out of nothing, *ex nihilo*, "gave it an intrinsic value as the result of the direct will of God" (Hannam, 2009, p. 41). Thus both pagans and Christians believe that the world is imperfect, but the pagan would attribute it to the material the Creator was forced to use and the Christian would blame it on the Fall (p. 41).

Historically, it was widely believed that matter has always existed, supporting the pagan belief. In the last century it was recognized that matter is largely empty space. For example, 99.99% of mass of the atom is contained in the nucleus, which is a mere trillionth of the atom's volume, and the rest is empty space. Likewise, protons are made out of two up quarks and one down quark and mostly empty space. Neutrons consist of two down quarks and one up quark and mostly empty space. Cornell professor Carl Sagan succinctly summarized the composition of matter as follows: "Matter is composed chiefly of nothing" (Sagan, 1980, p. 218). This observation is the basis of the conclusion that the big bang primordial egg, from whence came the entire universe, was the size of an atom or smaller (Barrow, 2000).

The Creation of Humans

The problems inherent in dating an instantaneous, supernatural creation are illustrated by the creation of the first man, Adam. If a modern onlooker assumed that Adam was born an infant as are modern humans, he would conclude that Adam was about 20 years old when, in fact, he was only about one day old. This does not imply that the Creator is deceptive but reflects the fact that the human body *had* to be created fully formed and functional in order to exist as a living organism. The onlooker's false assumptions as to how Adam originated would contrast with the fact that Adam himself would not draw a wrong conclusion since he knew that he was created into a form that we recognize as an adult and had not yet witnessed childbirth or children at the time.

If Adam's blood were not already circulating in his circulatory system when he was created, the few minutes required to prime his circulation system could cause major cell death or damage. Furthermore, all of Adam's organs—including his heart, lungs, kidneys, brain, etc.—must have been functioning simultaneously as a unit the instant that he was created. In other words, Adam must have been created as a fully mature young man. Likewise, when Eve was created, Adam would have known that she was only a day or so old, yet she would have appeared as a fully mature adult (Poythress, 2006, p. 117).

For this reason, even though Adam was created instantaneously, he would be evaluated by many modern physiological measurements to be a 20-year-old man the moment he was created (Poythress, 2006). If examined medically, much unequivocal scientific evidence in support of a 20-year age would be verified. An example is bone ossification measurements that evaluate the level of conversion of cartilage into bone as the child develops. Medical tests, interpreted on the assumption that Adam was born as a baby, would conclude that Adam was, and would have to be treated medically as if he were, in fact, in the prime of his life, even though he was less than a few days old.

Although a physician who completed an examination on Adam the day he was created might conclude from scientific development measures, such as bone-to-cartilage ratios, that Adam was 20 years old, some evidence for an age much less than 20 might also be found. For example, if Adam were created *ex nihilo* today, we might not detect certain effects of aging (such as DNA and RNA damage) in a one-day-old Adam that exist in the average 20-year-old male today. The possibility cannot be ruled out that some evidence, such as tissue culture examination of his cells, may have existed to prove that Adam was, in fact, one day old. Likewise, lack of both tooth wear, cosmic ray damage, and other signs of aging may also have indicated an age of a few days old instead of 20 years old.

Kyle Butt notes that this example provides evidence that everything God made during the Creation week was

> formed complete and fully functional. For instance, how old were Adam and Eve two seconds after God created them? They were literally two seconds old! Yet they walked, talked, and looked like adult human beings, and even had the ability to reproduce (Butt, 2002, p. 40-R).

We know that the Garden of Eden appeared old because it had fully grown trees with fruit on them when created. DeYoung defines the mature creation concept as follows:

> The earth, solar system, Milky Way Galaxy, and entire universe were brought into existence supernaturally during six 24-hour days. Top soil and trees appeared virtually instantaneously in the Garden. Fully-grown animals were miraculously formed on land and in the air, complete with symbiotic relationships. The seas instantly swarmed with creatures, great and small, that had never been born or developed from infancy. Our first parents, Adam and Eve, were adults from their first breaths. The sun's nuclear fusion furnace began on

> Day 4, at full power and in thermodynamic equilibrium. Starlight from distant stars was created in transit, complete with a virtual history of information embedded within the light waves. Adam and Eve could look at the night sky their first evening on Earth and see cosmic light sources much as we do tonight. To an observer the completed creation on Day 6 was fully functioning in a steady state (DeYoung, 2010, p. 54).

Questions such as whether Adam had a navel (since he was not born of a woman) and whether the first trees had rings (the trees would have been fully grown, and fruit trees would have fruit on them, giving the appearance of age) all need to be explored, but these questions are more in the area of philosophy and theology rather than science. Another question: would ground erosion be evident at the time of Adam, aside from that caused by newly created rivers, a moment after they were created? Apparent age cannot be proven scientifically but is a hypothesis based on conjecture that can help us to understand the past. John Morris wrote that if an

> observer from a different universe, with no knowledge of Adam's creation, traveled to earth on Day Seven and tried to determine Adam's age (or the age of a rock, or the age of a star), how could it be done? He would rely on today's human growth rates (or rates of radioactive decay, or the speed of light), calculate how long it would take for this state of maturity to develop, and come to a *wrong* conclusion (Morris, 2010, p. 15).

This is exactly the problem faced today in endeavoring to date all ancient events.

Can Naturalism Explain Life?

For life to exist, living creatures must have a means of taking in and biochemically processing, food, water, minerals, and other materials. Life also requires the intake of oxygen that must be distributed to all tissues. For single-celled life, oxygen must enter through the cell membrane and effectively and safely move around inside of the cell to where it is needed without permanently damaging the cell. Without irreducibly complex mechanisms to achieve these tasks, life cannot exist (Behe, 1996). The parts could not appear separately and could not even exist independently for very long because, without protection, they would rapidly deteriorate from the effects of dehydration, oxidation, and other environmental insults (Overman, 1997).

Given both the scientific and scriptural constraints, creating a living body one part at a time, such as creating a liver, then a femur bone, etc., until the body was eventually complete, would not be a viable method. Even if these parts existed, the many parts required for life could not sit around idly waiting for the other parts to appear because they would rapidly deteriorate. No other method appears to exist to produce life other than by instantaneously creating a fully functioning, complete living organism. This does not preclude the possibility that changes may have occurred since that time, only that a certain level of complexity must exist before both a living organism and a functioning universe can exist.

The same problem exists even with a single cell. DNA is useless without: (1) all of the complex machinery required to produce mRNA, such as RNA polymerase, and (2) the machinery required to translate the mRNA code into protein such as a ribosome. Furthermore, a ribosome is only one of multiple proteins that the cellular machinery produces from mRNA. Hundreds of complex proteins are necessary for a cell to be alive and, therefore, a functional cell could have been created only as a complete functioning unit, not as individual parts. The view that life could evolve naturally via the "frontloading" of very precise initial conditions, such as the genes, to allow life to evolve, is the subject for a future paper. In short, I believe this view is untenable, and so far little evidence exists for this position.

Evolution cannot account for all of the parts necessary for life coming together at one time and being properly assembled and activated as a unit in a timely manner so that it will produce life. Since evolution cannot explain this problem, and it has been documented that this approach is not feasible, only an instantaneous creation and assembly of all of the necessary parts into a functioning unit can produce life. No compelling evidence has ever been produced to disprove this conclusion, and much evidence exists for the instantaneous creation requirement, such as the discovery that most nucleotides rapidly degrade at the temperatures that scientists speculate existed on the early earth (Irion, 1998).

This view was explained by Whitcomb and Morris (1961, p. 369), who noted that a common proof for an ancient age of the universe is the fact that far galaxies "are known to be some few billion light-years away" from the earth and since "by definition it has taken that number of years for their light to reach us; therefore they are at least that old, so the argument goes." They then add the interpretation that this:

> begs the question. It constitutes an implicit denial that the universe could have been created as a functioning entity. If creation has occurred at all (and the two principles of thermodynamics require this) then it is reasonable that it would have been a *complete* creation. It must have had an "appearance of age" at the moment of creation. The photons of light energy were created at the same instant as the stars from which they were apparently derived, so that an observer on the earth would have been able to see the most distant stars within his vision at that instant of creation. There is nothing

> unreasonable either philosophically or scientifically in this, although it does contradict the uniformitarian assumption (Whitcomb and Morris, 1961, p. 369).

They stress that:

> the Bible quite plainly and irrefutably teaches the fact of a "grown" Creation—one with an "apparent age" … analogous to the "apparent age" of a mature Adam at the first instant of his existence. This Creation must have included all the chemical elements already organized in all the organic and inorganic chemical compounds and mixtures necessary to support the processes of the earth and of life on the earth (Whitcomb and Morris, 1961, pp. 344–345).

Whitcomb and Morris (1961, p. 238) conclude, "There could be no *genuine* creation of any kind, without an initial appearance of age inherent in it."

Another example is that the sun must have been able to heat and light the earth on the day it was created. Although it takes only eight minutes for the sun's light to reach the earth, it takes an estimated 10,000 to 170,000 years for the gamma rays produced in the sun's core to reach the sun's surface as visible photons due to the absorption and reemission path taken as the photons journey outwards (Sturrock, 1985). For the sun to heat the earth the day it was created the photons must have been created in transit as if millions of years had passed. In other words, it was created with the appearance of age. As Reymond (1998, p. 396) stated, the "creation would of necessity require that some aspects of the universe would have come from the hand of its creator with an appearance of age."

Eighteenth-century naturalist Philip Gosse's main argument for the appearance-of-age view was that since both living and nonliving things existed in never-ending cycles, God created everything in the act of progressing in its cycle—egg to chicken, chicken to egg, oak to acorn, then to oak, and again to acorn in an endless cycle. Life would reproduce and develop, with animals having skin, blood, and bones when created, all making them appear to someone who falsely assumes that all current processes must be extrapolated into the past older than they actually were when created. This theory he called *prochronism*, or "outside of time" (Gosse, 1857).

As a result, all examinations of the post-Creation world would reveal a world that appeared to have been created somewhere within the normal cycle and, as a result, would look old. Stephen Gould states that he finds "Gosse's argument quite satisfactory as a solution" to the "which came first, the chicken or the egg" problem but added "within the boundaries of his assumptions," which was creationism, a view that Gould stressed he does not agree (Gould, 1985, p. 106).

Creation of the Universe

The validity of the analogy of comparing the creation of a human body with the creation of the universe has been supported by recent findings. Nobel laureate George Wald even stated that he believed the universe was designed for life, a view for which he concluded the evidence is overwhelming. As an example, he stated that the elements carbon, hydrogen, oxygen, and nitrogen "have unique properties" required for life that are not shared by any other element in the periodic table of the elements (interview in Levy, 1998, p. 12).

Furthermore, the earth is a system involving many complex feedback cycles. A well-known example is that the earth must have an oxygen cycle, a carbon cycle, a nitrogen cycle, a sulfur cycle, a hydrologic cycle, and numerous other interconnected cycles in order to sustain life on the planet. Just as Adam must have been created as a living being with blood and other cycles (such as the Krebs cycle) functioning in his body, so too the earth must have been created with all of its cycle systems functioning to allow life to be able to live on it.

Research has confirmed the view that the earth and the entire universe is an extraordinarily well-organized, complex machine: our earth is part of an organized solar system that is, in turn, part of a highly organized group of stars called a galaxy (in our case the Milky Way Galaxy) that is part of a highly organized family of galaxy clusters called the Local Group (the Milky Way's home) that in turn are organized into an enormously large groups of clusters called superclusters.

Likewise, because the solar system is interrelated at all levels, the Creator could not have created the earth as a single entity existing alone in the universe, but rather must have created the entire solar system (both the heavens and the earth) as a complete functioning unit, just as Adam must have been created as a living being within a very short period of time. For example, according to researchers, if the moon did not exist, the earth would rotate three times faster than it currently does, a recurrent gale-force wind like that on Jupiter would exist, making higher animal life as we know it impossible, the tides would be much lower, reducing the recirculation of shoreline nutrients and the dilution and removal of pollutants that would otherwise accumulate along the shore (Comins, 1993). Furthermore, the same dependent relationship exists with the other planets; among other functions Jupiter and Saturn serve to protect the earth from cataclysmic destruction (Gonzalez and Richards, 2004).

As God created the universe for a reason (including as a support system for life on earth, as noted in the discussion of the moon above) and, as He must have created Adam with blood *moving* in his veins, it is not unreasonable to infer that the stars were created with their light in transit (Whitcomb and Morris, 1961, p. 369). Although other theories exist to explain the fact that we can see stars that are millions of light years away, such as Russell Humphrey's white hole cosmology (Humphreys, 1994), the mature creation view can effectively explain how distant supernovae can be seen from the earth within a Biblical time framework. Just as many medical tests on a day-old Adam would indicate he was then a 20-year-old man, likewise, the astronomical evidence would indicate a mature universe on the day it was created (Poythress, 2006). Although the universe would be mature, and thus appear to be millions of years old, as in the case of Adam, this model predicts that some scientific tests would indicate a young universe. This may be one reason why contemporary dating techniques produce different dates for the creation of the earth and the universe.

Future research will ideally determine other reasons for these common discrepancies, but in the meantime the apparent-age hypothesis explains them quite well. It does not account for all science findings, such as the different ages obtained from using a variety of radiometric tests on a single sample. Although the appearance-of-age belief may not currently be provable by science, it may, nonetheless, be the most reasonable conclusion from the few explanations that now exist. The fact is:

> no infallible, scientific young-earth or old-earth argument is known. That is, every old-earth argument has a young-earth rebuttal, and vice versa. What decades of research on chronology show is the difficulty in absolutely dating any aspect of the earth or the universe. There remains before us a wide spectrum of age interpretations depending on one's perspective (DeYoung, 2010, p. 58).

DeYoung adds that it is currently:

> premature to assume that any current creation model is the final word, including the mature option. Later research may show otherwise. The mature creation view does not scientifically explain all the difficult questions such as seeing detailed information in distant starlight, but this is not a sufficient reason to abandon or ridicule the position. Every model of origins, whether sacred or secular, has its full share of unanswered questions (DeYoung, 2010, p. 56).

Arguments Against this View

A common argument against this view is that it can be used to conclude that the universe is any age, even only two minutes old (Dembski, 2003). In fact, if the *ex nihilo* creation requires the appearance of age, how old the universe is (or anything else, such as how old all life actually is) is a separate question. If an *ex nihilo* creation is valid, this does not necessarily preclude determining the actual age of certain aspects of the universe and life in it by traditional empirical methods in conjunction with other sources of information, such as historical records. Use of different dating methods to determine the age of something is one method to determine its age. If the dates are consistent, this indicates, but does not prove, that the date determined may be valid.

For both life and nonlife, the concordance method may not be useful to determine the actual age. For example, many different tests on our one-day-old Adam would all point to a 20-year-old man; yet other tests, such as for atherosclerosis or DNA damage, may not be typical of a 20-year-old man. Just as all tennis balls must be round, likewise, all *ex nihilo* creations will have the appearance of age to one who assumes the object of interest is old. Even a wood pencil created *ex nihilo* would have the appearance of age, because pencils require growing a tree, then cutting it down, kiln drying the wood, shaping it into a pencil, painting it yellow, attaching an eraser and other requirements to produce a pencil.

Vern Poythress makes an excellent case for the appearance-of-age view, concluding that what he calls the mature creation view "is a clear and simple explanation for the conclusions of modern astronomy" as well as geology and even physics (Poythress, 2006, p. 116). He adds that the "universe appears to be 14 billion years old because God made it mature," and he also speculates that the "universe is *coherently* mature, in the sense that estimates of age deriving from different methods arrive at the similar results." On this point I am arguing that the universe appears old due to the constraints of creating a fully functional universe *ex nihilo,* but it will manifest some clear evidence of youth.

Miracles

The fact often ignored in the age debate, by both sides of the creation controversy, is that creation *ex nihilo* is not a natural process. Rather it is a miracle. Exploring miraculous events illustrates the problems of ignoring this fact. A good example of a miracle is an event often called the "most spectacular of Jesus' miracles," the resurrection of Lazarus of Bethany, the brother of Mary and Martha (Sanders, 1962, p. 103). Jesus raised Lazarus from the dead after Lazarus had been in the grave for four days, long enough for his body to begin major levels of decomposition. It is for this reason that the scriptural account describes his body as having a strong, unpleasant smell.

Both modern and ancient medicine would regard the resurrection of Lazarus as an impossible event, and this is likely the point of the miracle. Others Jesus raised from the dead had only recently died (namely, Jairus's daughter in Mark 5:22–43 and the son of the widow at Nain in Luke 7:11–17), and some argue that they were only in a coma from which they were revived. For this reason, some accept these events as historical because, they argue, those resurrected persons were actually not dead (Mark 5:39). Thus, what Jesus did was not a miracle and proved nothing about him except that he was a fraud.

Sanders (1992, p. 103) notes that many scholars argue that the raising of Lazarus involved such "formidable difficulties as to make it impossible to accept it as historical." But this is the point—when a body smells, it means that the stomach acids have begun to hydrolyze the body's internal tissues and that the intestinal bacteria has begun digest connective tissue and other body carbohydrates. However, writing books arguing that Lazarus's resurrection was medically impossible does not prove that the event did not occur, only that it was a miracle. This is the whole point of the account.

The creation of the earth presents the same situation. Science has some evidence that indicates the modern earth required 4.6 billion years to form naturally and, therefore, the earth's creation in a week is a far greater miracle than raising Lazarus and, consequently, is greater evidence of the Creator's power. Evidence that the earth must have required 4.6 billion years to form only supports the extent of the miracle of its creation. For this reason the creation is regarded as both the first and the greatest miracle of God (Gen. 1:1; 2 Peter 3:5).

Another example of a miracle is Christ's conversion of water into wine (John 2:7–11). Scientifically, this is impossible because water contains hydrogen and oxygen in a two to one ratio. Wine contains water, plus a carbon-based compound called ethyl alcohol or ethanol, and various flavors and other components. If a scientist discovered a simple way to instantaneously convert water into wine, it would prove that Jesus was simply a smart person, not a miracle worker as portrayed in the Scriptures. A key element in the story is time. Water can indeed be converted into wine, but in addition to time it requires grape vines, sunlight, a photosynthesis system, a fermentation metabolic pathway, and the proper enzymes to catalyze the entire process. Scientifically, what Christ did was impossible, and again this is the point. Jesus performed a natural process instantaneously, not in a year or so as is normally required to produce wine from grapes using water.

If a chemist measured the molecular components of the wine that had never actually been converted from grape sugar by bacteria, the wine may even be identified as the product of a local vineyard, even though it had never been produced from harvested grapes. The reason is because *ex nihilo*-created wine would be expected to contain detailed chemical information, just as starlight contains spectral details (DeYoung, 2010).

Some argue that claiming a history for something that never happened, such as creating wine instantaneously, an entity that requires much history in order to be naturally produced, is deceptive. Creating wine from water was openly described as a miracle, and those who were familiar with the situation were not misled. In fact, the whole point of the event was to demonstrate God's power so that those reading about the event would know the wine was not made from grapes. It had no history but rather was a miracle that lacked a history. This was a purposeful communication of power and divinity.

As it is a "strain to fit the history of the world into a biblical 6,000 years" (Gardiner, 2009, p. 132), it is also a strain to convert water into wine in a few seconds, or to turn back the clock on a dead man. If these events actually occurred, as the Bible and Christians have believed for 2,000 years, all these events are miracles. To be consistent, all miracles should be accepted, or all of them should be rejected. Many Christians reject the latter view but rather attempt to divide miracles into the "easier" miracles—such as changing water into wine—and more difficult miracles, such as the resurrection of Lazarus. Most often, though, all Biblical miracles are divided into the most difficult miracle, *ex-nihilo* creation, which many Christians reject, and all other miracles, which many Christians reason could occur, such as the resurrection of the dead.

Is God a Deceiver?

A major objection to the appearance-of-age theory is that if God made the earth appear older than it actually is, then He has deceived us because the earth is not, in fact, as old as it appears. Haarsma and Haarsma wrote that the appearance of age:

> would mean that God embedded in the universe a host of evidence that indicates a long, richly detailed history that never happened. Sedimentary layers look like they formed in a muddy sea bottom, except the sea never existed. … Igneous rock layers look like they were formed from repeated volcanic outflows, but the volcano never erupted. Would God have created the earth with evidence of a rich, complicated history that is completely false? … this seems dishonest. … Of course, God is omnipotent and could have created it this way if he chose, but the Appearance of Age Interpretation seems inconsistent with what we know about God as taught in the rest of the Bible. "The heavens declare the glory of God" (Ps. 19:1). This verse and many other Scripture passages teach that God reveals himself to us truthfully through the natural world (Haarsma and Haarsma, 2007, pp. 93–94).

They conclude by asking, "Would God really ask us to believe the earth is 10,000 years old in spite of abundant geological evidence that it is billions of years old?" In response to this query Sibley wrote:

> God did not deliberately set out to create things that look old, but that

> in creating he made things complete and whole; thus Adam and Eve, the animals and plants were created as mature entities having the appearance of age, not because of a desire to deceive on God's part, but out of his sovereign choice to make beings with physical maturity, an entirely sensible decision bearing in mind the need for parental care towards the immature (Sibley, 2009, pp. 94–95).

Kyle Butt concludes that the deception claim would be valid except that:

> God told us what he did! He did not leave us in the dark or try to "trick us" or "test our faith" by hiding from us important information that He knew we would need. Rather, He was very straightforward and honest with us. Considering the material found in the first eleven chapters of Genesis (and elsewhere throughout the Bible), no one can justifiably accuse God of deception (Butt, 2002, p. 40-R).

Conversely, John Morris adds that if "scientists extrapolating present process *are* right and the universe *is* old, then God *has* lied to us, for He clearly said He created all things in six days, not too long ago" (Morris, 2010, p. 15). Mature creation is deception only if one outright assumes that the apparent age is fact. When Eve was created, Adam would have known exactly how old she was. God could not be accused of having deceived Adam because Eve looked like an adult female, and anyone who did not know how old she actually was would judge her to be an adult. This observation also applies to the whole age controversy. In answer to the question "How old is the Earth?" Butt notes that no one knows the exact age of the earth but by:

> using biblical chronology, a person can calculate the age of the Earth to be in the neighborhood of 6,000 years old. "But the Earth looks millions of years old," some people have protested. There are at least two responses to such a statement. First, one might ask: "Compared to what; what does a young Earth look like?" We obviously do not have another Earth that we know is younger than this one, so how would we know what a young Earth looks like. Second, it should not surprise us if science occasionally calculates older dates for the Earth, due to a concept known as the "doctrine of apparent age" (Butt, 2002, p. 40-R)

The fact is, not one functional thing exists that could be created *ex nihilo* that would not have the appearance of age. Even a simple rock created *ex nihilo* would appear to be very old. For example, an igneous rock such as granite that was created instantaneously would manifest evidence of a past molten state even though it did not form as a result of solidification from a once molten state. Even a single molecule, such as a monatomic molecule of osmium, that was created instantaneously would have the appearance of age (including the time required for nucleosynthesis by a supernova event, ejection from the nova, a journey in space, accretion and, finally, becoming part of planetary formation).

The History of the Concept

Mature creation was a common conclusion of many early Bible scholars and theologians. Philo of Alexandria (c. 20 BC—AD 50) wrote that when God created the universe He "produced the whole race of trees out of the earth in full perfection, having their fruit not incomplete, but in a state of entire ripeness, to be ready for the immediate and undelayed use and enjoyment" of the animals (Yonge, 1993, p. 7). Saint Basil of Caesarea (c. AD 330—379) wrote:

> In a moment earth began by germination to obey the laws of the Creator, completed [in] every stage of growth, and brought [seed] germs to perfection. The meadows were covered with deep grass, the fertile plains quivered with harvests, and the movement of the corn was like the waving of the sea. Every plant, every herb, the smallest shrub, the least vegetable, arose from the earth in all its luxuriance. There was no failure in this first vegetation: no husbandmans inexperience, no inclemency of the weather (Schaff and Wace, 1978, Vol. 8, p. 78).

Although the appearance-of-age view dates to Biblical times, the most widely known exposition of the idea by a scientist was by the respected naturalist and eminent zoologist, Philip Gosse, a Fellow of the Royal Society. In 1857 he published a book titled *Omphalos*, Greek for "belly button," referring to the idea that Adam would have a belly button even though he was not born of a woman. Gosse, an accomplished author, illustrator, and researcher, provided numerous examples that he believed supported the idea of the appearance of age.

In *Omphalos* Gosse asked, "Would the earth and all its various interconnected systems look different than they do now *if* the world was created in an instant by a single creative act?" To explore this question, Gosse took an imaginative journey back to the earth's creation, examining what existed then. For example, he explored whether the instantly created trees that sprouted from the ground at the creation had rings or seeds. He also wondered which came first, the chicken or the egg, concluding that the only possible answer is that both *must* have been created at the same time, namely a chicken that contained an egg, which needed to be fertilized to produce another chicken.

He documents that every living and nonliving thing in the world is part of an interconnected temporal system, and its four-dimensional nature goes to its very core. Nature cannot be created *ex nihilo* without creating everything, including time, *ex nihilo*, and it must have been created as a functioning system just like Adam's body.

Gosse's main argument is that *if* the world was created out of nothing by an act of creative power, *then* there could exist no physical evidence of the point in time at which that creation took place. The world is like a spinning top and, if it was created, it must have been created spinning, and no finger marks will be on it, nor any evidence of an outside cause of its acceleration. It will start its existence spinning as if it had spun for some time before it was actually created. Haarsma and Haarsma (2007, p. 93) wrote that this:

> interpretation says that God really did create the earth in six twenty-four-hour days less than 10,000 years ago, but God constructed it to *look* ancient. Appearance of Age was suggested as early as the 1800s and is still advocated by some.

As we have documented, God did not construct it to look ancient, but creation *ex nihilo* and miracles require the appearance of age. If creation *ex nihilo* occurred, the appearance of age must follow. Furthermore, this interpretation goes back to long before Christ walked on earth and was not originated in the 1800s.

Life and Information

Both the plant and animal kingdoms manifest enormous complexity and information in their genetic codes, but this order and information must preexist if the animal or plant inherited it and passed it on through reproduction. Except for the "world" made by humans, the natural world operates according to preexisting physical laws and previous events. The living world, which we are only now beginning to understand, represents a level of design and complexity based on information existing in the genetic code that is found nowhere else in the nonliving world.

Hence, the rationale for the belief that the living world could not have evolved from the nonliving world but must have been created *ex nihilo*, either here or somewhere else in the universe (Hoyle, 1982, 1983). Harvard molecular biologist, Dr. Edmond Kornfield, stated over a half century ago that in his scientific work he has frequently:

> been overwhelmed by a sense of the infinite wisdom of God. So highly intricate are the organic and biochemical processes functioning in the animal organism, that ... one is rather amazed that a mechanism of such intricacy could ever function properly at all. All this demands a planner and sustainer of infinite intelligence. As I continue my labors, my belief in God is progressively strengthened and the attitude of unbelieving colleagues, anywhere in the world, becomes more and more an inexplicable conundrum. The simplest man-made mechanism requires a planner and a maker. How a mechanism ten times more involved and intricate can be conceived of as self-constructed and self-developed is completely beyond me (Kornfield, 1958, p. 176).

The enormous amount of genetic information that is translated into the complexity evident everywhere in the living world is far beyond that found in both the nonliving and human-manufactured world. In spite of this fact, some still argue that humans are a mere "glorious accident" (Kayzer, 1997). Products produced by the nonliving world (such as smooth stones polished by moving water) could never produce either plant or animal life because all life is based on enormous amounts of information, and the parts produced by that information must be assembled according to a designed plan in an environment, such as a certain ecosystem, that supports life (Schroeder, 2001; Yockey, 1992; Behe, 1996). Likewise, the universe contains clear evidence of design that indicates it was assembled to support life. This design is logically explained as the result of an *ex nihilo* creation of complete functional units.

The view that the universe had to be assembled instantaneously in order to function does not argue against the models articulated by Russell Humphreys and other cosmologists, but is a factor that can be considered when evaluating both the empirical data and other models. Humphreys (1994) concluded that when God created the stars, some were created with the appearance of an age of billions of years, i.e., they were created "fully grown," having all the characteristics of being mature—without having existed for billions of years to become mature naturally.

In researching this paper much support for the appearance-of-age view was located. One of many examples is University of Pittsburgh professor of astronomy David Snoke, who concluded, " I view the idea of 'apparent age' as viable in regard to the creation" of the earth and the universe, and cited many Scriptures that support this view (Snoke, 2006, p. 174). Even secular support was noted. One evolutionist, Professor John Wagner, wrote:

> Most undergraduate students take geology courses as the perceived least painful option to fulfill their institution's general education laboratory science requirements … Many of these students, especially in large state-assisted schools … bring religious viewpoints and perspectives to their studies which espouse profoundly negative views about evolution and the geologic time scale. Students in this category will grudgingly memorize the minimum amount of geological information they need to pass the course, but will let the instructor know that they don't believe a word of it is true. This type of situation doesn't help the student, the class morale, or the greater goal of scien-

> tific literacy for all people (Wagner, 2005, p. 194).

The solution that he found very successful in both physical and historical geology classes is:

> to introduce the concept of apparent age prior to discussing the geological time scale or the age of the earth in the lecture setting. By acknowledging up front that special creation is a possible option, so long as that creation carries the imprint of apparent age, the tension among students is relieved and geological processes and concepts can be investigated in good conscience based on the apparent age of rocks, fossils, or landscapes. With students no longer on the defensive, they are free to study geology without feeling like they are betraying their religious faith (Wagner, 2005, p. 194).

For Further Research

This paper can only briefly introduce the topic. Questions for further research include whether a mature creation would include fossils (I believe it would not), whether the Fall caused a change in the apparent history of the world, and whether mature creation could account for some of the evidence for a universal Flood. At least three levels of the mature creation view exist: (1) a minimalist or functional view, the view generally advocated in this paper; (2) a total view such as promoted by Phillip Henry Gosse, who argued that everything from tree rings to fossils were created-nihilo; and (3) a partial view as promoted by Henry Morris, which takes a middle-of-the-road position between these two views. These basic views are summarized by Rusbult as follows.

- **Minimal Apparent Age**: this theory limits the appearance of old age to those features necessary for immediate functionality, including sunlight that was created in transit to the earth.
- **Total Apparent Age**: This view argues that God created a universe with a complete apparent history, with accurate data (including nonessential details) about what would have happened since the beginning. If current theories of astronomy are correct, God created a universe that looks exactly the same as if it had been created by a big bang billions of years ago.
- **Partial Apparent Age**: This in-between view concludes that some nonessential apparent age exists but not a total apparent history (summarized from Rusbult, 2004, p. 1).

Another concern is that although we estimate the age of something based on certain assumptions of how it came to be, not simply by its appearance, different assumptions lead to vastly different age estimates, regardless of the appearance of the object in question. Assumptions that involve dating objects need to be evaluated in more detail. All of these topics require another paper, ideally a Ph.D. thesis, and involve many nonscientific assumptions that go beyond the scope of this review. Some of these questions cannot be answered scientifically, such as "Did Adam have a navel?" because we do not today have a body to examine. At this time the answer to this question is a matter of belief, some concluding because Adam was perfect he must have had a navel and others concluding that since he was not born of a woman he could not have had a navel.

Summary

This paper has argued that the appearance-of-age concept is a viable hypothesis for explaining the existence of life and, possibly, even the physical universe that must be considered when researching the age problem. If historic creation *ex nihilo* belief is true, the appearance-of-age conclusion *must* also be true: "A real creation [*ex nihilo*] would of necessity require that some aspects of the universe would have come from the hand of its Creator with an appearance of age" (Reymond, 1998, p. 396).

The creation of the universe and life is by far the greatest miracle ever and provides the best and most impressive evidence of a miracle by a miracle-working Creator. Notice that *ex-nihilo* created reality tends to give false age estimates only if we assume they were not supernaturally created. The problem is that scientific attempts to estimate the age of something involve not only present measurements, but also assumptions about the history of the object in question. As Haarsma and Haarsma (2007, p. 93) note, the appearance of age theory:

> neatly avoids all conflict between what nature says and what Scripture says about natural history. Unlike other concordist interpretations, the scientific evidence cannot disprove this view: whatever science finds is the way God made it appear. Thus no scientific problems arise with this view.

Furthermore, "those who favor a mature creation are in good company. It is a historically-rich position as demonstrated by many Bible scholars, past and present" (DeYoung, 2010, p. 59).

References

Barrow, J. 2000. *Book of Nothing*. Pantheon, New York, NY.

Behe, M. 1996. *Darwin's Black Box*. Free Press, New York, NY.

Butt, K. 2002. What is the doctrine of apparent age? *Reason and Revelation* 1(10):40–41.

Comins, N. 1993. *What If the Moon Didn't Exist?* Harper Collins, New York, NY.

Dembski, W. 2003. *The Design Revolution: Answering the Toughest Questions about Intelligent Design*. InterVarsity Press, Downers Grove, IL.

DeYoung, D. 2010. Mature creation and seeing distant starlight. *Journal of Creation* 24(3):54–59.

Gardiner, J. 2009. At liberty to divulge.

American Scholar. 87(2):131–133.

Gonzalez, G., and J. Richards. 2004. *The Privileged Planet*. Regnery, New York, NY.

Gosse, P. 1857. *Omphalos. An Attempt to Untie the Geological Knot. John Van Voorst*, London, England.

Gould, S. 1985. *The Flamingo's Smile: Reflections in Natural History*. W.W. Norton, New York, NY.

Haarsma, D., and L Haarsma. 2007. *Origins: A Reformed Look at Creation, Design, & Evolution*. Faith Alive Christian Resources, Grand Rapids, MI.

Hannam, J. 2009. *God's Philosophers: How the Medieval World Laid the Foundations of Modern Science*. Icon Books, London, UK.

Hoyle, F. 1982. The universe: past and present reflections. *Annual Reviews of Astronomy and Astrophysics*, 20:1–36.

Hoyle, F. 1983. *The Intelligent Universe*. Holt, Rinehart and Winston, New York, NY.

Humphreys, R. 1994. *Starlight and Time: Solving the Puzzle of Distant Starlight in a Young Universe*. Master Books, Green Forest, AR.

Irion, R. 1998. Ocean scientists find life, warmth in the seas. *Science* 279:1302–1303.

Kayzer, W. 1997. *A Glorious Accident—Understanding Our Place in the Cosmic Puzzle*. W.W. Freeman, New York, NY.

Kornfield, E. 1958. God-alpha and omega. In Monsma, J. (editor), *The Evidence of God in an Expanding Universe*, pp. 174–178. G. P. Putnam, New York, NY.

Levy, D. 1998. Four simple facts behind the miracle of life. *Parade Magazine*. June 12, p. 12.

Monsma, J. 1958. *The Evidence of God in an Expanding Universe*. G. P. Putnam, New York, NY.

Morris, J. 2010. Creation with the appearance of age. *Acts & Facts* 39(12):15.

Overman, D. 1997. *A Case Against Accident and Self-Organization*. Rowman & Littlefield, New York, NY.

Poythress, V. 2006. *Redeeming Science: A God-Centered Approach*. Crossway Books, Wheaton, IL.

Reymond, R. 1998. *A New Systematic Theology of the Christian Faith*. Thomas Nelson Publishers, Nashville, TN.

Rusbult, C. 2004. Apparent age (part 2). Three "appearance of age" views—Phillip Gosse, Henry Morris, Ken Ham. http://www.asa3.org/ASA/education/origins/aa2-cr.htm. See also http://www.asa3.org/ASA/education/origins/aa.htm

Sagan, C. 1980. *Cosmos*. Random House, New York, NY.

Sanders, J.N. 1962. Lazarus of Bethany. In Buttrick, G. (editor), *The Interpreter's Dictionary of the Bible*. Abingdon Press, New York, NY.

Schaff, P., and H. Wace (editors). 1978. *A Select Library of Nicene and Post-Nicene Fathers of the Christian Church*, Vol. VIII. Wm. Eerdmans, Grand Rapids, MI.

Schroeder, G. 2001. *The Hidden Face of God: How Science Reveals the Ultimate Truth*. The Free Press, New York, NY.

Sibley, A. 2009. The nature and character of God. In Nevin, Norman (editor), *Should Christians Embrace Evolution?* pp. 93–107. InterVarsity Press, Nottingham, UK.

Snoke, D. 2006. *A Biblical Case for an Old Earth*. Baker, Grand Rapids, MI.

Sturrock P. 1985. *Physics of the Sun: The Solar Interior*. Springer, New York, NY.

Wagner, J. 2005. Using the concept of apparent age to defuse creationist confrontations in the classroom. *Geological Society of America Abstracts with Programs* 37(7):194.

Whitcomb, J.C., and H.M. Morris. 1961. *The Genesis Flood*. Presbyterian and Reformed Publishing Company, Philadelphia, PA.

Yockey, H. 1992. *Information Theory and Molecular Biology*. Cambridge University Press, Cambridge, UK.

Yonge, C.D. 1993. *The Works of Philo: Complete and Unabridged*. Hendrickson Publishers, Peabody, MA.

Author and Title INDEX for Volume 47, 2010–2011

Lazella M. Lawson*

This title/author index covers articles, panorama notes and other features. For items with two or more pages, the reference is to the first page only. After the page number, a letter indicates which type of entry is involved: article (A), panorama note (P), letter to the editor (L), book or video review (R), cover photo (CP), or other departments (such as editorials, laboratory director's comments, president's remarks, photo essays, etc.) (D).

A

Akridge, Jerry A.
  Response to Michael Oard's Article Questioning our Post-Flood Interpretation of the Fossil Animals Identified at Ashfall Fossil Beds State Historical Park, Nebraska, A., 324 (L)
  Sequoyah Caverns: A Testimony of the Genesis Flood, 96 (A)

Amber—The Natural Time Capsule, Don B. DeYoung, 110 (R)

Anderson, Kevin
  CRS Conference Abstracts, 229 (D)
  Guilty as Charged, 256 (D)
  It's Time for Atheists to Get Real, 4 (D)

Annie's Box, Don B. DeYoung, 228 (R)

Ar/Ar Dating Process/Evaluation of the, Richard L. Overman, 23 (A)

Armitage, Mark H.
  Can a Laboratory Make an Authentic Fossil? 59 (P)
  Grateful Comments, 312 (L)
  The Little Oxygenators that Could: Cyanobacteria, 305 (P)
  The Mighty Triangle: A Microscopic Hammer of Design, 296 (P)
  Pyrenoids and Evolution: Why Abandon a Great Idea? 66 (P)

Armstrong, Bruce G.
  Sun at Midnight: The Rudolf Steiner Movement and Gnosis in the West, 204 (R)

Author and Title Index for Volume 46, Lazella Lawson, 171 (D)

B

Barnhart, W.R.
  How Blind Are We? Reading a Picture, 303 (P)

Bergman, Jerry
  Friedrich Nietzsche's Superman, a Child of Darwin, 205 (A)
  Hitler's Ethic: The Nazi Pursuit of Evolutionary Progress, 137 (R)
  The Mystery of Trilobite Evolution, 33 (A)
  The Search for Evidence Concerning the Origin of Fish, 283 (A)
  The Origin of Trees, 259 (A)
  The Rise and Fall of the Orthogenesis Non-Darwinian Theory of Evolution, 139 (A)
  Should Christians Embrace Evolution? 191 (R)

Beware the "Best-in-Field" Fallacy, John K. Reed and Michael J. Oard, 169 (L)

---

*Lazella M. Lawson, Newhall, CA

Biblical Evidence for Demise of the Dinosaurs, John Jameson, 162 (L)

Board of Directors Meeting Minutes, Gary Locklair, 237 (D)

Branscome, Gary Ray
  Klenck's Errant Interpretation, 313 (L)

Brown, Colin
  The Origin of the Whale, 161 (L)
  Quest for the Original Type of Man, 312 (L)

C

The Call of the Wild, Don DeYoung, 331 (R)

Can a Laboratory Make an Authentic Fossil? Mark H. Armitage, 59 (P)

Can "Relative" Radiometric Dating Help Refine Biblical Chronology? John K. Reed and Carl R. Froede Jr., 70 (P)

Censored Science, The Suppressed Evidence, Don DeYoung, 332 (R)

Censored Science, The Suppressed Evidence, Clifford L. Lillo, 212 (R)

Chaffin, Eugene
  Is the Georeactor Hypothesis Plausible? 158 (P)

Cosmos, Creator and Human Destiny: Answering Darwin, Dawkins, and the New Atheists, Nick Sabato, 333 (R)

Creation, Fall, Restoration: A Biblical Theology of Creation, Jeremy Maurer, 336 (R)

Creation or Evolution? Consider the Evidence before Deciding, George F. Howe, 337 (R)

CRS Conference Abstracts, Kevin Anderson, 229 (D)

Cuthbertson, Simon
  Supporting Klenck's Model, 245 (L)

D

The Dark Side of Charles Darwin, Wayne Frair, 340 (R)

The Demise of Dinosaurs: Some Potential Objections, David Guyon, 79 (L)

The Demise of Dinosaurs, Reagan Shcrock, 80 (L)

"Demise of Dinosaurs" Revolutionary, Cole Hammond, 162 (L)

The Demise of the Dinosaurs before the Flood: Biblical and Paleontological Correlations (response), Joel D. Klenck, 164 (L)

DeYoung, Don B.
  Amber—The Natural Time Capsule, 110 (R)
  Annie's Box, 228 (R)
  The Call of the Wild, 331 (R)
  Censored Science, The Suppressed Evidence, 332 (R)
  Mokele-Mbembe: Mystery Beast of the Congo Basin, 44 (R)
  The New Creationism, 203 (R)
  Redeeming Science, 8 (R)
  Science, Creation and the Bible, 338 (R)

Discovery of Design: Searching Out the Creator's Secrets, Jeremy Maurer, 43 (R)

Duncan, Hamilton
  Volcanism "Fountains of the Great Deep" and Forty Days of Rain, 9 (A)

E

Earth's Catastrophic Past: Volumes 1 and 2, Jackie Lee, 240 (R)

Earth's Magnetic Field Is Decaying Steadily—with a Little Rhythm, D. Russell Humphreys, 193 (A)

Erkel, Michael
  Cover Designs by Michael Erkel and Associates, (CP)

Evolution, Science, and Scripture: Selected Writings of B.B. Warfield, John Goertzen, 30 (R)

Excellent and Frightening Article/An, J. Hooper, 244 (L)

F

The Fall: Impact of the Demise of the Dinosaurs and Geological Stratigraphy (response), Joel Klenck, 81 (L)

Fossil Facts & Fantasies, Andrew Ste. Marie, 21 (R)

Foth-Regner, Kitty
  Slaughter of the Dissidents, 202 (R)

Frair, Wayne
  The Dark Side of Charles Darwin, 340 (R)
  Rational Conclusion, 333 (R)

Friedrich Nietzsche's Superman, a Child of Darwin, Jerry Bergman, 205 (A)

Froede, Carl R. Jr.
  Can "Relative" Radiometric Dating Help Refine Biblical Chronology? 70 (P)

G

Galileo Goes to Jail and Other Myths about Science and Religion, Jonathan F. Henry, 20 (R)

Genesis Model for the Origin, Variation, and Continuation of Human Populations/A, Joel David Klenck, 111 (A)

Geographic Information Systems: A Mapping Revolution, Jacqueline Lee, 74 (P)

Georeactor Hypothesis Plausible?/Is the, Eugene Chaffin, 158 (P)

God and Evolution, Theodore J. Siek, 341 (R)

Goertzen, John
  Evolution, Science, and Scripture: Selected Writings of B.B. Warfield, 30 (R)

Grand Canyon, Part III: A Geomorphological Problem/The Origin of, Michael J. Oard, 45 (A)

Grand Canyon, Part IV: The Great Denudation/The Origin of, Michael J. Oard, 146 (A)

Grand Canyon, Part V: Carved by Late Flood Channelized Erosion/The Origin of, Michael J. Oard, 271 (A)

Grateful Comments, Mark H. Armitage, 312 (L)

Guilty as Charged, Kevin Anderson, 256 (D)

Guyon, David
  The Demise of Dinosaurs: Some Potential Objections, 79 (L)

H

Habermehl, Anne
  No Evidence for Pre-Flood Demise of the Dinosaurs, 163 (L)

Hammond, Cole
  “Demise of Dinosaurs” Revolutionary, 162 (L)

Hennigan, Tom
  The Origin of Trees, 259 (A)

Henry, Jonathan F.
  Galileo Goes to Jail and Other Myths about Science and Religion, 20 (R)

Hitler’s Ethic: The Nazi Pursuit of Evolutionary Progress, Jerry Bergman, 137 (R)

Holman Quick Source Guide to Understanding Creation, Stanley V. Udd, 242 (R)

Hooper, J.
  An Excellent and Frightening Article, 244 (L)

How Blind Are We? Reading a Picture, W.R. Barnhart, 303 (P)

Howe, George F.
  Creation or Evolution? Consider the Evidence before Deciding, 337 (R)

Humphreys, D. Russell
  Earth’s Magnetic Field Is Decaying Steadily—with a Little Rhythm, 193 (A)

I

It’s Time for Atheists to Get Real, Kevin Anderson, 4 (D)

J

Jameson, John
  Biblical Evidence for Demise of the Dinosaurs, 162 (L)

Jones, Brian
  Making Fossils, 243 (L)

K

Klenck, Joel D.
  The Demise of the Dinosaurs before the Flood: Biblical and Paleontological Correlations (response), 164 (L)
  The Fall: Impact of the Demise of the Dinosaurs and Geological Stratigraphy (response), 81 (L)
  A Genesis Model for the Origin, Variation, and Continuation of Human Populations, 111 (A)
  Klenck Responds—Genesis Model: Theological and Archaeological Considerations, 317 (L)
  Klenck Responds—Genesis Model: Theological and Archaeological Considerations, Joel D. Klenck, 317 (L)

Klenck’s Errant Interpretation, Gary Ray Branscome, 313 (L)

Klenck’s Nephilim Model Stacks Assumptions upon Speculations, David Woetzel, 314 (L)

Klevberg, Peter
  The Little Ice Age in the North Atlantic Region, Part I: Introduction to Paleoclimatology, 213 (A)

L

Lawson, Lazella
  Author and Title Index for Volume 46, 171 (D)

Lee, Jacqueline
  Earth’s Catastrophic Past: Volumes 1 and 2, 240 (R)
  Geographic Information Systems: A Mapping Revolution, 74 (P)

Life’s Story: The One That Hasn’t Been Told (DVD), Jeremy Maurer, 109 (R)

Lightner, Jean
  When Helping Hurts: How to Alleviate Poverty without Hurting the Poor… and Yourself, 339 (R)

Lillo, Clifford L.
  Censored Science, The Suppressed Evidence, 212 (R)

The Little Ice Age in the North Atlantic Region, Part I: Introduction to Paleoclimatology, Peter Klevberg and Michael J. Oard, 213 (A)

The Little Oxygenators that Could: Cyanobacteria, Mark H. Armitage, 305 (P)

Locklair, Gary
  Board of Directors Meeting Minutes, 237 (D)

M

Making Fossils, Brian Jones, 243 (L)

Maurer, Jeremy
  Creation, Fall, Restoration: A Biblical Theology of Creation, 336 (R)
  Discovery of Design: Searching Out the Creator's Secrets, 43 (R)
  Life's Story: The One That Hasn't Been Told (DVD), 109 (R)
  The Mysterious Islands: A Surprising Journey to Darwin's Eden (DVD), 192 (R)
  Our Created Moon: Earth's Fascinating Neighbor, 32 (R)
  Questions for Klenck, 313 (L)
  Radioactive and Radiocarbon Dating: Turning Foe into Friend, 58 (R)

Michael Oard's Response, Michael Oard, 327 (L)

The Mighty Triangle: A Microscopic Hammer of Design, Mark H. Armitage, 296 (P)

"Missing" Decay: An Analysis of C-14 Detected in Very Old Samples/A Case of, Rick Sanders, 184 (A)

Mokele-Mbembe: Mystery Beast of the Congo Basin, Don DeYoung, 44 (R)

More Evidence for Klenck's Model, A.T. Smith, 246 (L)

The Mysterious Islands: A Surprising Journey to Darwin's Eden (DVD), Jeremy Maurer, 192 (R)

N

The New Creationism, Don B. DeYoung, 203 (R)

No Evidence for Pre-Flood Demise of the Dinosaurs, Anne Habermehl, 163 (L)

O

Oard, Michael J.
  Beware the "Best-in-Field" Fallacy, 169 (L)
  The Little Ice Age in the North Atlantic Region, Part I: Introduction to Paleoclimatology, 213 (A)
  Michael Oard's Response, 327 (L)
  The Origin of Grand Canyon, Part III: A Geomorphological Problem, 45 (A)
  The Origin of Grand Canyon, Part IV: The Great Denudation, 146 (A)
  The Origin of Grand Canyon, Part V: Carved by Late Flood Channelized Erosion, 271 (A)

The Origin of Fish/The Search for Evidence Concerning, Jerry Bergman, 283 (A)

The Origin of Trees, Tom Hennigan and Jerry Bergman, 259 (A)

The Origin of the Whale, Colin Brown, 161 (L)

Orthogenesis Non-Darwinian Theory of Evolution/The Rise and Fall of the, Jerry Bergman, 139 (A)

Our Created Moon: Earth's Fascinating Neighbor, Jeremy Maurer, 32 (R)

Our Undiscovered Universe: Introducing Null Physics, Stanley V. Udd, 332 (R)

Overman, Richard L.
  Evaluation of the Ar/Ar Dating Process, 23 (A)

P

Pyrenoids and Evolution: Why Abandon a Great Idea? Mark H. Armitage, 66 (P)

Q

Quest for the Original Type of Man, Colin Brown, 312 (L)

Questions for Klenck, Jeremy Maurer, 313 (L)

R

Radioactive and Radiocarbon Dating: Turning Foe into Friend, Jeremy Maurer, 58 (R)

Rational Conclusion, Wayne Frair, 333 (R)

Reed, John K.
  Beware the "Best-in-Field" Fallacy, 169 (L)
  Can "Relative" Radiometric Dating Help Refine Biblical Chronology? 70 (P)

  The Ultimate Proof of Creation: Resolving the Origins Debate, 40 (R)
  Response to Michael Oard's Article Questioning our Post-Flood Interpretation of the Fossil Animals Identified at Ashfall Fossil Beds State Historical Park, Nebraska, A. Jerry Akridge, 324 (L)

Redeeming Science, Don B. DeYoung, 8 (R)

S

Sabato, Nick
  Cosmos, Creator and Human Destiny: Answering Darwin, Dawkins, and the New Atheists, 333 (R)

Sanders, Rick
  A Case of "Missing" Decay: An Analysis of C-14 Detected in Very Old Samples, 184 (A)

Science, Creation and the Bible, Don B. DeYoung, 338 (R)

Sequoyah Caverns: A Testimony of the Genesis Flood, Jerry A. Akridge , 96 (A)

Sherock, Reagan
  The Demise of Dinosaurs, 80 (L)

Should Christians Embrace Evolution? Jerry Bergman, 191 (R)

Siek, Theodore J.
  God and Evolution, 341 (R)

Slaughter of the Dissidents, Kitty Foth-Regner, 202 (R)

Smith, A.T.
  More Evidence for Klenck's Model, 246 (L)

Ste. Marie, Andrew
  Fossil Facts & Fantasies, 21 (R)

Sun at Midnight: The Rudolf Steiner Movement and Gnosis in the West, Bruce G. Armstrong, 204 (R)

Supporting Klenck's Model, Simon Cuthbertson, 245 (L)

T

Trilobite Evolution/The Mystery of, Jerry Bergman, 33 (A)

U

Udd, Stanley V.
  Holman Quick Source Guide to Understanding Creation, 242 (R)
  Our Undiscovered Universe: Introducing Null Physics, 332 (R)

The Ultimate Proof of Creation: Resolving the Origins Debate, John K. Reed, 40 (R)

V

Volcanism "Fountains of the Great Deep" and Forty Days of Rain, Hamilton Duncan, 9 (A)

W

When Helping Hurts: How to Alleviate Poverty without Hurting the Poor… and Yourself, Jean Lightner, 339 (R)

Woetzel, David
  Klenck's Nephilim Model Stacks Assumptions upon Speculations, 314 (L)

Notes from the Panorama of Science

Blackbody Radiation and Creation

Introduction

The Genesis account of Creation, and in particular the creation of light on the first day of Creation Week, was the subject of a previous article examining the meaning and interpretation of the wording of the first chapter of Genesis (DeRemer et al., 2007). In that previous discussion, we presented evidence for the view that light and atoms were brought into existence after the *ex nihilo* creation of a substance referred to in English translations with the word "earth." Hence, one would be drawn to the modern ideas of atomic matter and blackbody radiation. The blackbody radiation would not exist before the formation of light and atoms, but would appear with their formation.

Because the original "earth" was the only substance available at the beginning of the first day, it is logical that God used it as the raw material from which to form light. And since light and atoms cannot exist without each other, it is logical that God formed some atoms at the same time. This conclusion is supported by God's evaluation of light as "good" in Genesis 1:4, from which we can infer that it was complete. For light to be complete, it required sources and absorbers, which are the atoms. At this stage of Creation, one would expect the interaction between light and matter to establish a localized volume that is in a state of thermal equilibrium. This would mean that light obeyed all the physical laws that have been found related to it, such as Planck's law of radiation. Here I am not saying that God is bound by Planck's law as a principle above and superior to God, but rather that God established this volume of matter and energy in thermal equilibrium, obeying Planck's law only when He formed light and atoms, and not before.

Blackbody radiation was a major topic of research in the late 1800s. By 1900, experiments that measured radiation from cavities in different solid materials had revealed that the amount of radiation at any wavelength that exits from a hole in the cavity is independent of the material but dependent on its temperature. The temperature dependence of the radiance can be expressed as

$$R = \sigma T^4$$

where R is the radiance, σ is the Stefan-Boltzmann constant (5.67 x 10^{-8} Watt/(meter^2 • K^4), and T is the temperature in Kelvins. For material in thermal equilibrium at room temperature (300 K), the radiance over the entire electromagnetic spectrum is 459 Watt/m^2.

On October 19, 1900, Max Planck announced to the Berlin Physical Society a theoretical formula that explained precisely the spectral radiance that can be expected from a cavity in any material. Planck developed his formula into what is now known as Planck's radiation law. He was the first person to quantize energy in order to derive this formula. His publication (Planck, 1901) signaled the beginning of the age of quantum mechanics.

The Planck blackbody radiation law is

$$W_\lambda = 2\pi \text{ x } 10^{-9} hc^2 \lambda^{-5} (e^{hc/\lambda kT} - 1)^{-1}$$

where W_λ is the spectral radiance normal to a perfect blackbody radiator surface, h is Planck's constant (6.625 x 10^{-34} Js [Joule second]), c is the speed of light (2.998 x 10^8 m/s [meters/second]), λ is the wavelength in nanometers (nm = 10^{-9} m), e is the base of natural logarithms (2.71828), k is Boltzmann's constant (1.3804 x 10^{-23} J/K [Joules/Kelvin]), and T is the temperature in Kelvins. Since most material surfaces are not perfect blackbody radiators, the blackbody spectral radiance calculated must be multiplied by the emissivity of the material's surface to determine the radiated power. We apply this law to the substance on the first day of Creation, when God created the heavens and the earth, before He spoke light into existence. We do this to show that if the original substance were atomic matter such as water, it would have emitted light from its surface.

Application of Planck's Radiation Law

Most popular Creation models (Ham, 1987; Morris, 1995; Humphreys, 1994; Brown, 2001; Williams and Hartnett, 2005) are based on the assumption that the "earth" created at the beginning had a surface that contained some molecular water (H_2O) in liquid form. Water is a liquid at temperatures ranging from 278–378 K (0–100 °C) and its emissivity varies from 0.93 to 0.95, depending on the temperature.

How much visible light would such an "earth" radiate? As input parameters for our calculation, we chose a nominal temperature of 300 K and an emissivity of 0.94. Visible light as a portion of the electromagnetic spectrum extends from λ = 430–690 nm. For the purpose of our sample calculation, we chose the visible wavelength of 600 nm. The spectral radiance at this wavelength from the surface of water would be 7.61 x 10^{-29} Watt/meter^2/nm. The radiance for the entire visible spectral range can be obtained by integrating the contributions from each of the visible wavelengths. A blackbody calculator (Spectralcalc.com, 2010) was used to calculate the total visible radiance, which is approximately 1.615 x 10^{-23} Watt/meter^2. Also, at 300 K the "earth" would glow the most at its peak wavelength above 9 micrometers in the infrared portion of the spectrum.

The total power radiated at visible wavelengths from a water surface can now be calculated if the area of the surface is known. In the popular models listed above, the surface area of the created "earth" varies between models from an area of the present planet Earth, which has a radius of 6.3 x 10^6 m (Brown, 2001), to the area of a sphere of water (Humphreys, 1994) with a radius of 1 light year (1 x 10^{15} m). The present Earth has a surface area of 5 x 10^{12} m^2, and a sphere of water with a radius of one light year has a surface area of 1.3 x 10^{31} m^2.

If the present Earth had only a water surface in thermal equilibrium at a temperature of 300 K, it would emit 8.1 x 10^{-11} watts of visible radiance. Humphreys's sphere of water would radiate 2.1 x 10^8 watts. Since visible light photons have an average energy of 3.5 x 10^{-19} J, these two original "earth" models would emit 2.3 x 10^8 and 6 x 10^{26} visible photons per second, respectively.

Discussion

We showed with the use of Planck's radiation law that liquid water emits visible photons as part of blackbody radiation. How the original earth substance became the chemical elements and electromagnetic radiation of our universe is something we are not told in the Genesis account, other than that God spoke light into existence. This is significant to the first day because we are told that God spoke light into existence sometime after the initial creation of the heavens and earth reported in Genesis 1:1. He most likely formed light on the morning of the first day because that was the beginning of the first period of daylight as reported in Genesis 1:5.

But did God create light from nothing at that time? A clue to the answer to this question is found in Genesis 1:4: "and God separated the light from the darkness." One interpretation of this verse is that light originally was combined with darkness and was separated out of the original dark earth substance. This interpretation is supported in Isaiah 45:7, where the Lord speaks of Himself as "the One forming light and creating darkness." It is reasonable to apply this verse to the first day as to any other time in history. God created the darkness mentioned in Genesis 1:2 at the beginning. Then, we believe (DeRemer et al., 2007), he formed light from the dark "earth" at dawn (the mid-point) of the first day.

It is our thesis that the darkness of the first day contained no electromagnetic radiation or free photons because the electromagnetic spectrum is continuous from gamma rays to radio waves, and that includes the visible spectrum. God formed the whole spectrum, only when, according to Genesis 1:3, "God said, 'Let there be light'; and there was light."

He could have done this by separating the original earthen material into both energy (photons) and particles that make up atoms (protons, electrons, neutrons). That original "earth" would have been the substance from which God formed all the energy and particles that are now contained in the universe. The original substance would not have been atomic matter but rather would have been in the form of a fluid that did not radiate. If it makes sense to speak of this fluid in the same terms as we use in our present universe, where atoms and light exist and interact, we would say the fluid had a temperature of 0 K. Without a temperature there would have been no blackbody radiation, hence no visible light, emitted from this substance.

We also speculated that God began the formation of atoms at the same time He formed light. Atoms are the sources and absorbers for photons of light. Also, the elementary particles and their antiparticles at the atomic level form a conversion pair with photons, in accordance with Einstein's formula $E = mc^2$, where E is energy (photons), m is the mass of the particles, and c is the speed of light. It is reasonable to assume that only after God made sources and absorbers for light would He have declared it perfect as reported in Genesis 1:3–4. These sources and absorbers would interact with light for all time.

Conclusion

Light, or electromagnetic radiation in general, is one of the most fundamental items that God made during Creation Week. It is one reason why He formed it so early in the week. However, the most fundamental substance created at the beginning is called "earth."

This original earth is described in Genesis 1:2: "The earth was formless and void, and darkness was over the surface of the deep; and the Spirit of God was moving over the surface of the waters." We conclude from this verse that the earth was not a planet because it was formless, it was not made of atomic matter because there was only total darkness over its surface (no light at all yet), it was deep in extent, and it was in the form of a fluid, so that it was described as "waters." Also, in Genesis 1:10 God named dry land earth. Dry land is a substance that can contain all the chemical elements and their compounds that naturally occur in the universe.

None of the popular Creation models listed above take into account the physical fact that all atomic matter emits electromagnetic radiation at a temperature above absolute zero. This physical fact is embodied in Planck's radiation law, as observed in our calculation above. What the actual substance was that God created at the beginning is not known. What is known is that the miracles God performed during the first four days converted that substance into all the chemical elements and physical objects in the universe.

Our article (DeRemer et al., 2007) presented a possible model that fits the description of the original earth given in Genesis 1:2. That model may or may not be correct, but it does not violate Planck's radiation law or the text that God has given mankind about His actions during the week of Creation. God told us a part of what He did to create and make the universe in that first chapter of Genesis. It is reported as a chain of miracles of both creating *ex nihilo* and making from previously created material. All that can be reasonably done is to explain the results of these reported miracles in what we consider scientific terms. But many details of the processes involved remain beyond our knowledge without further revelation from God.

Acknowledgment: All Scripture references are taken from the New American Standard Bible, 1977, copyright by the Lockman Foundation. Used by permission.

References

Brown, W. 2001. *In the Beginning*, 7th Edition, Center for Scientific Creation, Phoenix, AZ.

DeRemer, F., M. Amunrud, and D. Dobberpuhl. 2007. Days 1–4. *Journal of Creation* 21(3): 69–76.

Ham, K. 1987. *The Lie: Evolution*. Master Books, Green Forest, AR.

Humphreys, D. 1994. *Starlight and Time*. Master Books, Green Forest, AR.

Morris, H. 1995. *The Defender's Study Bible*. World Publishing, Grand Rapids, MI.

Planck, M. 1901. Ueber das Gesetz der Energieverteilung im Normalspectrum [On the law of energy distribution in the normal spectrum]. *Annalen der Physik, IV Folge* 309 (4):553–563.

Spectralcalc.com 2010. Blackbody calculator available online at: http://www.spectralcalc.com/blackbody_calculator/blackbody.php (as of March 14, 2011).

Williams, A., and J. Hartnett. 2005. *Dismantling the Big Bang*, Master Books, Green Forest, AR.

Delmar A. Dobberpuhl
Prescott, AZ
deljaned@cableone.net

Letters to the Editor

The policy of the editorial staff of CRSQ *is to allow letters to the editor to express a variety of views. As such, the content of all letters is solely the opinion of the author, and does not necessarily reflect the opinion of the* CRSQ *editorial staff or the Creation Research Society.*

Setting the Record Straight

In a *CRSQ* letter (Klenck, 2011, p. 321) written by Joel Klenck, it was stated that my book *Buried Alive* (1998) contained a "ploy" to sell more books. By this he was referring to the hectic chase in which certain men in sports cars followed us back to our borrowed apartment outside of Paris on August 18, 1979. Let me make this as short and truthful as possible. It happened just like I wrote it in the book. My entire family can testify to this frightening memory. I wish to thank the editor of *CRSQ* for the ability to set the record straight.

Jack Cuozzo

Klenck, J. 2011. Letters to the editor. *Creation Research Society Quarterly* 47:317–323.

The Age of the Oldest Placental Mammal Means Evolution is Wrong!

By the end of the Triassic most of the mammal-like reptiles that for the most part were too specialized to be the ancestors of mammals were gone. By mid-Jurassic the remainder had disappeared. At 200 million years ago we encounter a modern mammalian jaw hinge, and at 195 million years we have middle ear bones in a mammal called *Hadrocodium wui* (Gore, 2003).

At 164 million years is a remarkable mammal with modern fur and skin structure that has been given the name "Jurassic Beaver" (Helt, 2006, p.16). The oldest known monotreme is found at 160 million years old, and at the same age is a remarkable discovery from China—the placental mammal *Jeremiah sinensis* (Luo et al., 2011). There is nothing whatever contemporary with it except egg-laying mammals. The oldest marsupial is at 125 million years old. Just what the relationship is between placental mammals and marsupials—if any—remains to be seen.

The situation this placental mammal finds itself in is unique, as it is in a position where there is nothing that could have given rise to it; therefore there could have been no evolution whatsoever! It clearly goes back in time with a history of its own, which of course will make matters better for creation, and considerably worse for evolution. In fact, the latter will be removed from the real world altogether!

Colin Brown
Warrington
United Kingdom

Gore, R. 2003. The rise of mammals. *National Geographic* 203:2–38.

Helt, J. 2006. "Jurassic beaver" is new fossil record. *New Scientist* 189:16.

Luo, Zhe-Xi, Chong-Xi Yuan, Qing-Jin Meng, and Qiang Ji. 2011. A Jurassic eutherian mammal and divergence of marsupials and placentals. *Nature* 476:442–445.

Instructions to Authors

Submission

Electronic submissions of all manuscripts and graphics are preferred and should be sent to the editor of the *Creation Research Society Quarterly* in Word, WordPerfect, or Star-Office/Open Office (see the inside front cover for address). Printed copies also are accepted. If submitting a printed copy, an original plus two copies of each manuscript should be sent to the editor. The manuscript and copies will not be returned to authors unless a stamped, self-addressed envelope accompanies submission. If submitting a manuscript electronically, a printed copy is not necessary unless specifically requested by the *Quarterly* editor. Manuscripts containing more than 35 pages (double-spaced and including references, tables, and figure legends) are discouraged. An author who determines that the topic cannot be adequately covered within this number of pages is encouraged to submit separate papers that can be serialized.

All submitted manuscripts will be reviewed by two or more technical referees. However, each section editor of the *Quarterly* has final authority regarding the acceptance of a manuscript for publication. While some manuscripts may be accepted with little or no modification, typically editors will seek specific revisions of the manuscript before acceptance. Authors will then be asked to submit revisions based upon comments made by the referees. In these instances, authors are encouraged to submit a detailed letter explaining changes made in the revision, and, if necessary, give reasons for not incorporating specific changes suggested by the editor or reviewer. If an author believes the rejection of a manuscript was not justified, an appeal may be made to the *Quarterly* editor (details of appeal process at the Society's web site, www.creationresearch.org).

Authors who are unsure of proper English usage should have their manuscripts checked by someone proficient in the English language. Also, authors should endeavor to make certain the manuscript (particularly the references) conforms to the style and format of the *Quarterly*. Manuscripts may be rejected on the basis of poor English or lack of conformity to the proper format.

The *Quarterly* is a journal of original writings, and only under unusual circumstances will previously published material be reprinted. Questions regarding this should be submitted to the Editor (CRSQeditor@creationresearch.org) prior to submitting any previously published material. In addition, manuscripts submitted to the *Quarterly* should not be concurrently submitted to another journal. Violation of this will result in immediate rejection of the submitted manuscript. Also, if an author uses copyrighted photographs or other material, a release from the copyright holder should be submitted.

Appearance

Manuscripts shall be computer-printed or neatly typed. Lines should be double-spaced, including figure legends, table footnotes, and references. All pages should be sequentially numbered. Upon acceptance of the manuscript for publication, an electronic version is requested (Word, WordPerfect, or Star-Office/Open Office), with the graphics in separate electronic files. However, if submission of an electronic final version is not possible for the author, then a cleanly printed or typed copy is acceptable.

Submitted manuscripts should have the following organizational format:

1. Title page. This page should contain the title of the manuscript, the author's name, and all relevant contact information (including mailing address, telephone number, fax number, and e-mail address). If the manuscript is submitted by multiple authors, one author should serve as the corresponding author, and this should be noted on the title page.

2. Abstract page. This is page 1 of the manuscript, and should contain the article title at the top, followed by the abstract for the article. Abstracts should be between 100 and 250 words in length and present an overview of the material discussed in the article, including all major conclusions. Use of abbreviations and references in the abstract should be avoided. This page should also contain at least five key words appropriate for identifying this article via a computer search.

3. Introduction. The introduction should provide sufficient background information to allow the reader to understand the relevance and significance of the article for creation science.

4. Body of the text. Two types of headings are typically used by the *CRSQ*. A major heading consists of a large font bold print that is centered in column, and is used for each major change of focus or topic. A minor heading consists of a regular font bold print that is flush to the left margin, and is used following a major heading and helps to organize points within each major topic. Do not split words with hyphens, or use all capital letters for any words. Also, do not use bold type, except for headings (italics can be occasionally used to draw distinction to specific words). Italics should not be used for foreign words in common usage, e.g., "et al.", "ibid.", "ca." and "ad infinitum." Previously published literature should be cited using the author's last name(s) and the year of publication (ex. Smith, 2003; Smith and Jones, 2003). If the citation has more than two authors, only the first author's name should appear (ex. Smith et al., 2003). Contributing authors should examine this issue of the *CRSQ* or consult the Society's web site for specific examples as well as a more detailed explanation of manuscript preparation. Frequently-used terms can be abbreviated by placing abbreviations in parentheses following the first usage of the term in the text, for example, polyacrylamide gel electrophoresis (PAGE) or catastrophic plate tectonics (CPT). Only the abbreviation need be used afterward. If numerous abbreviations are used, authors should consider providing a list of abbreviations. Also, because of the variable usage of the terms "microevolution" and "macroevolution," authors should clearly define how they are specifically using these terms. Use of the term "creationism" should be avoided. All figures and tables should be cited in the body of the text, and be numbered in the sequential order that they appear in the text (figures and tables are numbered separately with Arabic and Roman numerals, respectively).

5. Summary. A summary paragraph(s) is often useful for readers. The summary should provide the reader an overview of the material just presented, and often helps the reader to summarize the salient points and conclusions the author has made throughout the text.

6. References. Authors should take extra measures to be certain that all references cited within the text are documented in the reference section. These references should be formatted in the current *CRSQ* style. (When the *Quarterly* appears in the references multiple times, then an abbreviation to *CRSQ* is acceptable.) The examples below cover the most common types of references:

Robinson, D.A., and D.P. Cavanaugh. 1998. A quantitative approach to baraminology with examples from the catarrhine primates. *CRSQ* 34:196–208.

Lipman, E.A., B. Schuler, O. Bakajin, and W.A. Eaton. 2003. Single-molecule measurement of protein folding kinetics. *Science* 301:1233–1235.

Margulis, L. 1971a. The origin of plant and animal cells. *American Scientific* 59:230–235.

Margulis, L. 1971b. *Origin of Eukaryotic Cells*. Yale University Press, New Haven, CT.

Hitchcock, A.S. 1971. *Manual of Grasses of the United States*. Dover Publications, New York, NY.

Walker, T.B. 1994. A Biblical geologic model. In Walsh, R.E. (editor), *Proceedings of the Third International Conference on Creationism* (technical symposium sessions), pp. 581–592. Creation Science Fellowship, Pittsburgh, PA.

7. Tables. All tables cited in the text should be individually placed in numerical order following the reference section, and not embedded in the text. Each table should have a header statement that serves as a title for that table (see a current issue of the *Quarterly* for specific examples). Use tabs, rather than multiple spaces, in aligning columns within a table. Tables should be composed with *14-point type* to insure proper appearance in the columns of the *CRSQ*.

8. Figures. All figures cited in the text should be individually placed in numerical order, and placed after the tables. Do not embed figures in the text. Each figure should contain a legend that provides sufficient description to enable the reader to understand the basic concepts of the figure without needing to refer to the text. Legends should be on a separate page from the figure. All figures and drawings should be of high quality (hand-drawn illustrations and lettering should be professionally done). Images are to be a minimum resolution of 300 dpi at 100% size. Patterns, not shading, should be used to distinguish areas within graphs or other figures. Unacceptable illustrations will result in rejection of the manuscript. Authors are also strongly encouraged to submit an electronic version (.cdr, .cpt, .gif, .jpg, and .tif formats) of all figures in individual files that are separate from the electronic file containing the text and tables.

Special Sections

Letters to the Editor:

Submission of letters regarding topics relevant to the Society or creation science is encouraged. Submission of letters commenting upon articles published in the *Quarterly* will be published two issues after the article's original publication date. Authors will be given an opportunity for a concurrent response. No further letters referring to a specific *Quarterly* article will be published. Following this period, individuals who desire to write additional responses/comments (particularly critical comments) regarding a specific *Quarterly* article are encouraged to submit their own articles to the *Quarterly* for review and publication.

Editor's Forum:

Occasionally, the editor will invite individuals to submit differing opinions on specific topics relevant to the *Quarterly*. Each author will have opportunity to present a position paper (2000 words), and one response (1000 words) to the differing position paper. In all matters, the editor will have final and complete editorial control. Topics for these forums will be solely at the editor's discretion, but suggestions of topics are welcome.

Book Reviews:

All book reviews should be submitted to the book review editor, who will determine the acceptability of each submitted review. Book reviews should be limited to 1000 words. Following the style of reviews printed in this issue, all book reviews should contain the following information: book title, author, publisher, publication date, number of pages, and retail cost. Reviews should endeavor to present the salient points of the book that are relevant to the issues of creation/evolution. Typically, such points are accompanied by the reviewer's analysis of the book's content, clarity, and relevance to the creation issue.

Creation Research Society Membership/Subscription Application and Renewal Form

The membership/subscription categories are defined below:

1. **Voting Member** .... Those having at least an earned master's degree in a recognized area of science.
2. **Sustaining Member** .... Those without an advanced degree in science, but who are interested in and support the work of the Society.
3. **Student Member** .... Those who are enrolled full time in high schools, undergraduate colleges, or postgraduate science programs (e.g., MS, PhD, MD, and DVM). Those holding post-doctoral positions are not eligible. A graduate student with a MS degree may request voting member status while enrolled as a student member.
4. **Senior Member** .... Voting or sustaining members who are age 65 or older.
5. **Life Member** .... A special category for voting and sustaining members, entitling them to a lifetime membership in the Society.
6. **Subscriber** .... Libraries, churches, schools, etc., and individuals who do not subscribe to the Statement of Belief.

All members (categories 1–5 above) must subscribe to the Statement of Belief as defined on the next page.

Please complete the lower portion of this form and mail it with payment to CRS Membership Secretary, P.O. Box 8263, St. Joseph, MO 64508-8263, or fax for credit card payment to (816) 279-2312. Applications may also be completed online at creationresearch.org.

This is a ☐ new ☐ renewal application for the subscription year beginning Summer ☐ 2011 ☐ __________. *(Please type or print legibly.)*

Name ______________________________ Address ______________________________

City ______________________ State ________ Postal/Zip code ____________ Country ______________

Phone (optional) ______________________________ Email ______________________________

Degree ______________________________ Field ______________________________

Year granted ______________ Institution ______________________________

Presently associated with ______________________________

I have read and subscribe to the CRS Statement of Belief. Signature ______________________________

For foreign orders, including Canadian, payment must be made in U.S. dollars by a check drawn on a U.S. bank, international money order, or credit card. *Please do not send cash.*

Indicate applicable category ⬇	*Indicate payment* ⬇			
	Paper**			**Paper-less‡**
☐ Voting ☐ Sustaining	USA	Canada Mexico	Other countries	
☐ Regular [per year]	☐ $35	☐ $53	☐ $70	☐ $31
☐ Senior [per year]	☐ $30	☐ $48	☐ $65	☐ $26
☐ Life member	☐ $500	☐ $500	☐ $500	☐ $500
☐ Student* [one year; multi-year not permitted]	☐ $30	☐ $48	☐ $65	☐ $26
☐ Subscriber [per year]	☐ $38	☐ $56	☐ $73	☐ $34

* Student members are required to complete the bottom portion of this form.

** Rates for the paper option include postage for First Class Mail International (FCMI), which is equivalent to airmail. Surface mail delivery is no longer available.

‡ **New PAPERLESS option:** You may now opt out of receiving paper copies of the CRS periodicals (*CRS Quarterly* and *Creation Matters*). By choosing this option you may register for access to the Premium Area of the website, where you may view or download electronic (PDF) versions of these publications. Of course, regular members and subscribers may also have access to the Premium Area. Only members, however, will have access to the Members Exclusive Area of the website.

Member/Subscriber $______ per year

(multi-year not permitted for students) x ______ years

SUBTOTAL $__________

Optional contribution + $__________

Life membership + $__________

TOTAL $__________

☐ Visa ☐ MasterCard ☐ Discover

☐ American Express ☐ Check/money order

Card number ______________________

Expiration date (mo/yr) ______________________

Phone number (______) ______________________

Signature ______________________

***Student Members* are required to complete the following:**

School or institution now attending ______________________

____

Your current student status: ☐ high school; ☐ undergraduate;
graduate program ☐ MS ☐ PhD; ☐ other ______________

Year you expect to graduate or complete your degree ______________

Major, if college or graduate student ______________

Signature ______________________

Order Blank for Past Issues

Cost of complete volumes (per volume): ....members (all categories) – $18.00 + S/H
nonmembers and subscribers (libraries, schools, churches, etc.) – $25.00 + S/H

Cost of single issues (per issue):......................members (all categories) – $5.00 + S/H
nonmembers and subscribers (libraries, schools, churches, etc.) – $7.00 + S/H

	Number			
Volume	1	2	3	4
21	☐	☐	☐	☐
22	☐	☐	☐	☐
23	☐	☐	☐	☐
24	☐	☐	☐	☐
25	☐	☐	☐	☐
26	☐	☐	☐	☐
27	☐	☐	☐	☐
28	☐	☐	☐	☐
29	☐	☐	☐	☐
30	☐	☐	☐	☐
31	☐	☐	☐	☐
32	☐	☐	☐	☐
33	☐	☐	☐	☐
34	☐	☐	☐	☐

	Number			
Volume	1	2	3	4
35	☐	☐	☐	☐
36	☐	☐	☐	☐
37	☐	☐	☐	☐
38	☐	☐	☐	☐
39	☐	☐	☐	☐
40	☐	☐	☐	☐
41	☐	☐	☐	☐
42	☐	☐	☐	☐
43	☐	☐	☐	☐
44	☐	☐	☐	☐
45	☐	☐	☐	☐
46	☐	☐	☐	☐
47	☐	☐	☐	☐
48	☐	☐		

CRSQ on CD, version 3.0

Reduced price!

Members, $75;
nonmembers and subscribers, $90.
Upgrade: Members, $30;
nonmembers and subscribers, $45.
(Prices include postage and handling.)

Two-set CD contains volumes 1–44 (through Spring, 2008) of the *Creation Research Society Quarterly* and volumes 1–12 (through December, 2007) of *Creation Matters* in PDF format.

Volumes 1–20 are available on CD. See "CRSQ on CD" advertisement on right for details.

Add 20% for postage (**for U.S. orders:** min. $5, max. $25; **for Canadian orders:** min. $10, no max.; **for other foreign orders:** min. $15, no max.)

Total enclosed: $_______________

Make check or money order payable to Creation Research Society. Please do not send cash. For foreign orders, including Canadian, please use a check in U.S. funds drawn on a U.S. bank, an international money order, or a credit card.

(Please type or print legibly)

Name ________________________ Address ______________________________________

City ______________________ State ________ Zip ______________ Country________________

❏ Visa ❏ MasterCard ❏ Discover ❏ American Express Card number ____________________________

Expiration date (mo/yr) ______________ Signature____

Mail to: Creation Research Society, 6801 N. Highway 89, Chino Valley, AZ 86323, USA

Creation Research Society

History—The Creation Research Society was organized in 1963, with Dr. Walter E. Lammerts as first president and editor of a quarterly publication. Initially started as an informal committee of 10 scientists, it has grown rapidly, evidently filling a need for an association devoted to research and publication in the field of scientific creation, with a current membership of over 600 voting members (graduate degrees in science) and about 1000 non-voting members. The *Creation Research Society Quarterly* is a peer-reviewed technical journal. It has been gradually enlarged and modified, and is currently recognized as one of the outstanding publications in the field. In 1996 the *CRSQ* was joined by the newsletter *Creation Matters* as a source of information of interest to creationists.

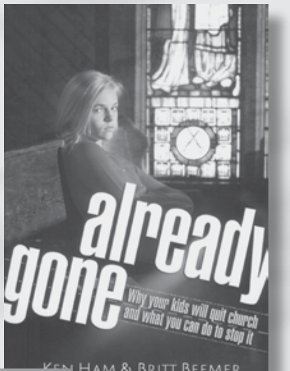
Activities—The Society is a research and publication society, and also engages in various meetings and promotional activities. There is no affiliation with any other scientific or religious organizations. Its members conduct research on problems related to its purposes, and a research fund and research center are maintained to assist in such projects. Contributions to the research fund for these purposes are tax deductible. As part of its vigorous research and field study programs, the Society operates The Van Andel Creation Research Center in Chino Valley, Arizona.

Membership—Voting membership is limited to scientists who have at least an earned graduate degree in a natural or applied science and subscribe to the Statement of Belief. Sustaining membership is available for those who do not meet the academic criterion for voting membership, but do subscribe to the Statement of Belief.

Statement of Belief—Members of the Creation Research Society, which include research scientists representing various fields of scientific inquiry, are committed to full belief in the Biblical record of creation and early history, and thus to a concept of dynamic special creation (as opposed to evolution) both of the universe and the earth with its complexity of living forms. We propose to re-evaluate science from this viewpoint, and since 1964 have published a quarterly of research articles in this field. *All members of the Society subscribe to the following statement of belief*:

1. The Bible is the written Word of God, and because it is inspired throughout, all its assertions are historically and scientifically true in all the original autographs. To the student of nature this means that the account of origins in Genesis is a factual presentation of simple historical truths.
2. All basic types of living things, including humans, were made by direct creative acts of God during the Creation Week described in Genesis. Whatever biological changes have occurred since Creation Week have accomplished only changes within the original created kinds.
3. The Great Flood described in Genesis, commonly referred to as the Noachian Flood, was a historical event worldwide in its extent and effect.
4. We are an organization of Christian men and women of science who accept Jesus Christ as our Lord and Savior. The act of the special creation of Adam and Eve as one man and woman and their subsequent fall into sin is the basis for our belief in the necessity of a Savior for all people. Therefore, salvation can come only through accepting Jesus Christ as our Savior.

CREATION RESEARCH SOCIETY
Resources

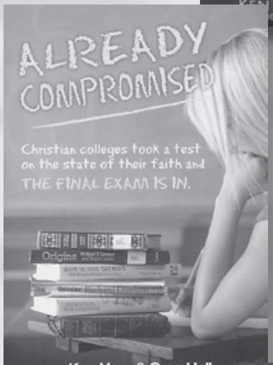

already gone
Why your kids will quit church and what you can do to stop it
Ken Ham & Britt Beemer

Already Gone

Ken Ham & Britt Beemer

Regular Price $11 + S/H / Member's Price $9 + S/H

Two-thirds of young people now attending evangelical churches will be gone after they leave home, because they have already left in their hearts. This shocking result comes from an in-depth poll of 1,000 young people aged 20 to 29 who have left the church. This book delves into the reason for this trend, including a high proportion who left because of the influence of evolution and the belief in an old earth.

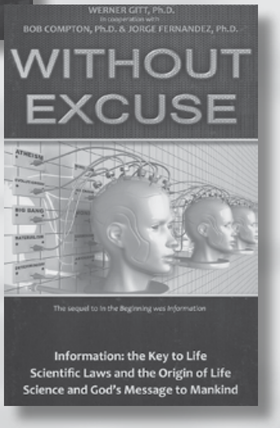

ALREADY COMPROMISED
Christian colleges took a test on the state of their faith and THE FINAL EXAM IS IN.
Ken Ham & Greg Hall
with Britt Beemer of America's Research Group

Already Compromised

Ken Ham & Greg Hall

Regular Price $14 + S/H / Member's Price $12 + S/H

Finally, a book that statistically documents the state of Christian colleges in regard to the origins issue, as well as biblical inspiration, inerrancy, and infallibility. The statistics are composed of the interviews of 312 university presidents, academic deans/vice presidents, heads of the science department, and heads of the theology/religion department.


WERNER GITT, Ph.D.
in cooperation with
BOB COMPTON, Ph.D. & JORGE FERNANDEZ, Ph.D.
WITHOUT EXCUSE
The sequel to In the Beginning was Information
Information: the Key to Life
Scientific Laws and the Origin of Life
Science and God's Message to Mankind

Without Excuse

Werner Gitt

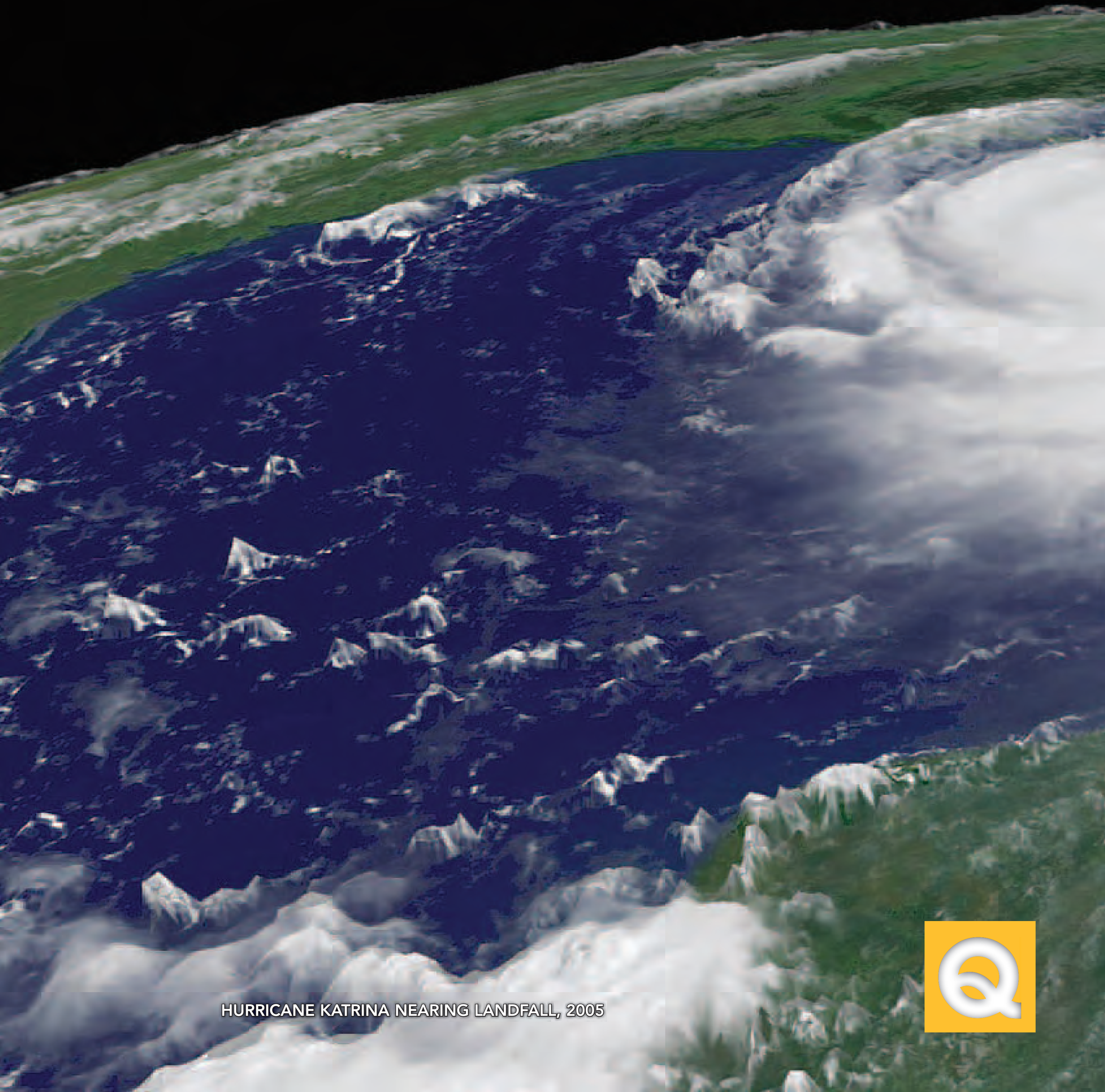
Regular Price $15 + S/H / Member's Price $13 + S/H

An academically rigorous sequel to Dr. Gitt's popular In the Beginning was Information. With his co-authors, information scientist Dr Werner Gitt provides an understanding of how all biological information comes from God.

Orders can by placed through
Creation Research Society, 6801 N. Highway 89, Chino Valley, AZ 86323-9186
Phone: 1-877-CRS-BOOK (1-877-277-2665); Fax: (928) 636-9921
www.creationresearch.org

For U.S. orders, add 20% for S/H (min $5, max $15)
For Canadian orders, add 20% for S/H (min. $5, no max.)
For foreign orders, add 25% for S/H (min. $15, no max.)
Orders must be pre-paid.

For credit card payments, (Visa, MasterCard, Discover, and American Express), please include the card number, expiration date (month/year), and your phone number.



HURRICANE KATRINA NEARING LANDFALL, 2005